Pluto's Diameter

The Hale telescope has now been used visually to measure the apparent diameter of Pluto, by Dr. G. P. Kuiper, of Yerkes and McDonald Observatories, and at the same time by Milton L. Humason, who co-operated in the observations and provided the observing time. The planet is now believed to have a diameter 0.45 times that of the earth, placing it between Mars and Mercury in order of size in the solar system, and corresponding to a linear diameter of about 3,550 miles.

A complete account of the new determination and of the reasons his earlier observations with the 82-inch McDonald reflector were not conclusive is given by Dr. Kuiper in the August issue of the *Publications* of the Astronomical Society of the Pacific. The values reported preliminarily at the Tucson meeting of the American Astronomical Society and discussed in Dr. Dirk Brouwer's article on current problems of Pluto, *Sky and Telescope*, March, 1950, must now be discarded in favor of the 200-inch results. The enigma of Pluto's mass once again becomes serious, for with a volume only about 1/10 the volume of the earth, the planet would have to have a density 10 times the earth's to provide the mass that seems to be perturbing Neptune, as described by Dr. Brouwer. In concluding his report, Dr. Kuiper says, "The mass determination is therefore not regarded as real, though no obvious explanation of the Neptune residuals is at hand."

The same technique, with a disk meter to produce a small artificial luminous disk of controllable brightness, color, and diameter, was used by Dr. Kuiper as in his previous attempts. By means of small diaphragms the f/ratio of the lens forming the artificial image is always made equal to the f/ratio of the main telescope. Diffraction effects in the two images to be compared are then identical, so they are eliminated in the comparison. Owing to the faintness of Pluto, no reliable results with the 82-inch telescope were obtained. The measurement of 0.4 second of arc, made on November 4-5, 1949, with the seeing 9 on a scale of 10 for several hours, was considered an upper limit to the real apparent size of the planet. It was concluded that further efforts would be futile and that the observation could be successful only with the 200-inch telescope, for this instrument would provide six times as much light in Pluto's image.

On March 14th the disk meter (folded to fit into the observing cage) was fitted to the prime focus mounting, and on March 21st, at 8:00 p.m. Pacific standard time, the observations were made, with seeing 6 on a scale of 10. The f/3.6 Ross corrector used by Mr. Humason in his photographic program was left in for reasons of safety, and as a check the diameter of an 11th-magnitude star was measured as well. The effective magnification was 1,170 diameters.

The apparent diameter of Pluto, then at a distance of 35.56 astronomical units, was found to be 0.22 second of arc, with a mean error of 0.01 second. The planet's zenith distance was only about 20 degrees. Mr. Humason made independent settings on Pluto and got the same result. The comparison star measured 0.11 second. The good seeing and the satisfactory figure on the mirror made the observation seem comparatively simple and direct. The comparison included artificial disks down to about one half of Pluto's diameter, and "it was established beyond doubt that the 200-inch result was a real measure and not merely an upper limit."

This diminished Pluto fits better with its faintness in the sky, and indicates a reflecting power, or albedo, of 0.17, much more reasonable than the value of 0.04 based on the assumption that the planet equals the earth in size. Dr. Kuiper suggests that the rocky surface of Pluto is invisible, for at its low temperature most of its original atmosphere will have frozen out. Both the remaining atmosphere and the condensation products prevent the albedo from being extremely low, as nearly all snows are white. Grit deposited by comets and meteors would darken the snows over the ages to approximately the proper amount to account for Pluto's color being so nearly that of sunlight, whereas Mercury, Mars, and the moon are considerably redder, because of their rocky surfaces. Dr. Kuiper estimates an atmosphere for Pluto less than 0.1 terrestrial atmosphere. The estimated mass of the planet is slightly below 1/10 that of the earth.

Sky and TELESCOPE

Copyright, 1950, by
SKY PUBLISHING CORPORATION

CHARLES A. FEDERER, JR., *Editor;* HELEN S. FEDERER, *Managing Editor*
EDITORIAL ADVISORY BOARD: *Clement S. Brainin*, Amateur Astronomers Association, New York; *Edward A. Halbach*, Milwaukee Astronomical Society; *Donald H. Menzel*, Harvard College Observatory; *Paul W. Merrill*, Mount Wilson Observatory; *Charles H. Smiley*, Ladd Observatory; *Percy W. Witherell*, Bond Astronomical Club.

VOL. IX, NO. 12
WHOLE NUMBER 108

OCTOBER, 1950

CONTENTS

COVER: A 17-inch reflecting telescope, combination Newtonian and modified Cassegrainian, designed and built by Paul R. Engle, and in operation at the New Mexico College of Agriculture and Mechanic Arts at Las Cruces, N. M. Photograph by Gilbert Moore, Physical Science Laboratory, State College, N. M. (See page 304.)

WESTERN AMATEURS' CONVENTION — H. A. Wallace 291
SOME STARS OF HIGH VELOCITY — Otto Struve 294
THE AMATEUR ASTRONOMER AS A COMMUNITY TEACHER — II — George W. Michalec 298
AMERICAN ASTRONOMERS REPORT 300

Amateur Astronomers 293
Books and the Sky 302
Gleanings for ATM's 304
Letters 306
News Notes 297
Observer's Page 307
Planetarium Notes 301
Stars for October 311
Terminology Talks 299

BACK COVER: The nebulosity near the star Eta Carinae, photographed with the 60-inch Rockefeller reflector at the Boyden station of Harvard Observatory, near Bloemfontein, South Africa, by M. J. Bester. The plate emulsion was Eastman 103aE, 90-minute exposure without filter. This panchromatic emulsion records both the blue and red ends of the spectrum. The scale of the reproduction is about 1° = 46 centimeters. East is at the top, south at the left. Harvard Observatory photograph transmitted by Bart J. Bok.

SKY AND TELESCOPE is published monthly by Sky Publishing Corporation, Harvard College Observatory, Cambridge 38, Mass. Entered as second class matter, April 28, 1939, at the Post Office, Boston, Mass., under Act of March 3, 1879; accepted for mailing at the special rate of postage provided in Paragraph 4, Section 538, Postal Laws and Regulations.

Subscriptions: $3.00 per year in the United States and possessions; countries in the Pan-American Postal Union, $3.50; Canada and all other foreign countries, $4.00. Make checks and money orders payable to Sky Publishing Corporation. Canadian and foreign remittances should be made in United States currency. Circulation department staff: Betty G. Dodd, manager; Nancy R. Bolton; Virginia K. McAuliffe.

All notices of change of address must be sent three weeks in advance and accompanied by old and new addresses, or we cannot make the proper change. When sending your renewal order, or writing in regard to your subscription, your current mailing address must be given. For most efficient handling of your subscription, please return our bill form with your renewal payment.

Editorial and advertising offices: Harvard College Observatory, Cambridge 38, Mass. Unsolicited articles and pictures are welcome, but we cannot guarantee prompt editorial attention, nor are we responsible for the return of unsolicited manuscripts unless return postage is provided by the author.

The second annual convention of western amateur astronomers, Palo Alto, Calif., August 14-16, 1950.

WESTERN AMATEURS' CONVENTION

By H. A. Wallace, *Peninsula Astronomical Society and Eastbay Astronomical Society*

Unofficially, the second annual convention of western amateur astronomers commenced on the Sunday evening before the opening meeting, when R. A. and Mark Allen Stolle, father and son, set up their 10-inch, f/11.2 portable reflector behind Roble Hall on the Stanford University campus. Nearly a third of the visitors had already arrived, and there was a burst of enthusiasm which never lagged until the last look at the Ring nebula and the bright little diamonds of M13 at Lick Observatory Wednesday night.

There was a total registration of 175, with delegates from most of the amateur astronomical societies on the Pacific Coast, of whom about 30 were women. Adequate facilities were made available by the university for rooms and meals, as well as large classrooms for the meetings and the numerous exhibits.

At the opening session Dr. Robert G. Aitken, that "friend of all astronomers," and retired director of Lick Observatory, gave an intimate talk stressing the delights of amateur astronomy and the opportunities for aiding in serious stellar research. He emphasized the desirability of proficiency in some one branch of amateur research rather than spreading the effort less efficiently over several.

This western amateurs' conference met for the first time last year under the auspices of the Los Angeles Astronomical Society at the suggestion of the late Professor G. Bruce Blair. A word of appreciation of Professor Blair was delivered by Carl E. Wells, of the Sacramento Valley Astronomical Society, a friend of long standing. Dr. Dinsmore Alter, president of the Astronomical Society of the Pacific and director of Griffith Observatory and Planetarium, presented some suggestions for planning a loose confederation among western amateurs and a tie-in alliance with the Astronomical Society of the Pacific, through which we could receive some rather important assistance. This was well received and, after a short discussion on the subject of a suitable vehicle, a resolution was unanimously adopted for the choosing of a committee of one member from each western amateur society and one appointed by unaffiliated amateurs. All are in high hopes that a very satisfactory arrangement will result.

The Monday afternoon meeting featured papers relating to observing. Thomas R. Cave, Jr., president of the Los Angeles Astronomical Society, was chairman and led off with "The Problem of Mars." Other papers were, "Sparks from Space," "An Apparent Mercurial-solar Relationship," "Amateur Variable Star Observations in 1912" (no, that 1912 is not a misprint), "Lunar Occultations," "The Saros and Prediction of Eclipses," "A Remarkable Saturnian Rotation Period," and "Consequences of Pluto's Newly Determined Diameter."

In order that the delegates might early become socially acquainted, the banquet was held on this first evening. Dr. Gerald E. Kron, of Lick Observatory, spoke on "Life on Mount Hamilton." He gave some interesting details of early days when the great refractor was driven by water power, which was rather inefficient during an especially dry season.

Among other prominent visitors were Dr. Seth B. Nicholson, of Mount Wilson and Palomar Observatories; Dr. Oliver Justin Lee, retired director of Dearborn Observatory; W. W. Baustian, engineer in charge of the housing for the new 120-inch reflector. Franklin B. Wright, of Schmidt-Wright camera fame, presented the convention with a description of his new development on the Herschelian telescope.

The star party was held after the banquet on the women's archery range. The public had been invited by newspapers and broadcasts; about 300 were on hand, showing considerable interest both in the telescopes and in amateur astronomy. The 20 instruments ranged from 10-inch aperture to a mounted periscope binocular. The skies were clear and the seeing perfect. A distant street light or two was not serious. To avoid unnecessary repetition, Jupiter being too conspicuous and tempting a target, it was arranged that the telescopes should be trained on certain available celestial objects in general accordance with the size of each instrument. In connection with the star party, a contest was held to determine

the best in optical perfection, mechanical perfection, and novel or unusual design. Several prizes had been donated by western manufacturers and these were awarded by a board of judges.

For optical perfection, first prize was awarded to Thomas R. Cragg for a 6-inch reflector, and Charles A. Fogus received honorable mention, for a 4-inch refractor. Chalmers B. Meyers received first prize for the mechanical design and construction of his 10-inch f/8 reflector, with honorable mention going to the Stolles for the instrument mentioned at the beginning of this article. As for novel design, Bruce C. Bowslaugh's Maksutov camera earned the award, with honorable mention to a 10-inch rich-field telescope by Marvin J. Vann. Among general exhibits, a Palomar model and planet models by Arthur W. Orton gained first honors, and the atomic models of John B. Underwood received honorable mention.

Papers for the second morning's meeting were on telescopes and accessory making, with Mr. Fogus, of the Sacramento Valley Astronomical Society, in the chair. He gave a paper on "A Roll-off Roof for an Observatory," which was followed by "The 120-inch Reflector for the Lick Observatory," "A New Kind of Herschel Telescope," "An Easier Way to Make a Better Pitch Lap," "Identifying the Stars," "Zonal Testing of Mirror Combinations with Light Source not at Center of Curvature," "Telescope Tripods," and "Building a 16-inch Telescope."

For the Tuesday afternoon and Wednesday morning sessions the papers were of general interest. Mr. Underwood, presiding, showed very interesting operating models of oxygen and other atoms to a scale of $1:10^n$, with description. Other papers included, "Organizing an Astronomy Club," "Galactic Rotation," "The Lowers — Amateurs Extraordinary," "Cosmology," "Problems of Rocket Travel," "Planetariums," and "The Oldest Astronomical Instrument."

On Tuesday evening Dr. Nicholson showed the motion picture, The Story of Palomar, in color, to which he added some remarks on recent results from the 200-inch. After this lecture many of the telescopes were again set up for observing without the public.

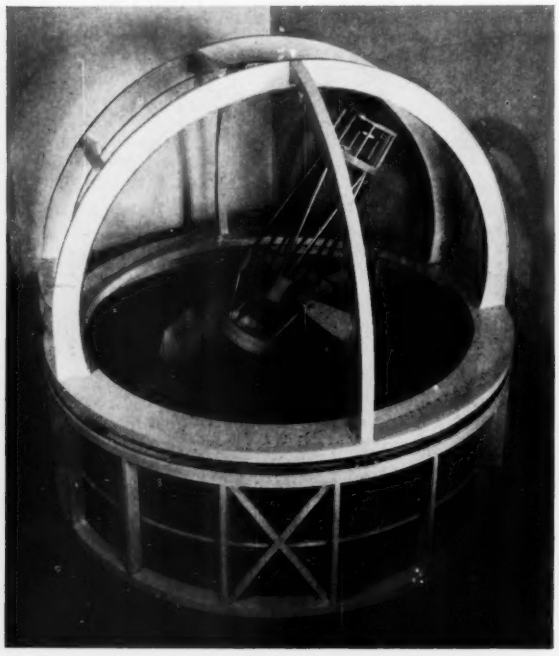
Dr. C. D. Shane, director of Lick Observatory, had invited the convention to Mt. Hamilton for the afternoon and evening of the final day. Since Palo Alto was but a few "terrestrial units" from Santa Clara University, where the famous Father Ricard pioneered in the study of sunspots, weather, and California seismology, we made that the first stop of the afternoon. The university kindly showed us the points of interest, including Father Ricard's study, library, and 12-inch Clark refractor.

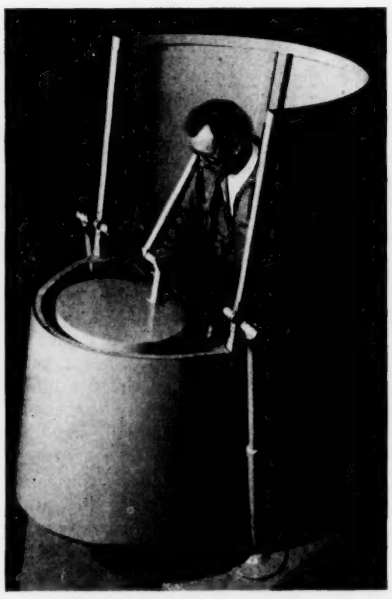
Next was the trip to Mt. Hamilton, with a motorcade of over 30 automobiles with seats for all. The ascent to the 4,000-foot elevation was increased by the necessity of climbing over two intervening ridges. As we arrived before five o'clock, the entire observatory could be visited in daylight, and we were enlightened by explanations and by answers to our questions. The site of the 120-inch reflector is in course of construction, the clearing and excavations completed and some concrete and steel placed. The astrographic cameras were visited, and the delegates were thrilled in viewing Arcturus in the guide telescope in bright sunshine. The current program includes a photographic record of the available northern heavens, the negatives to be stored for 50 years, when they can be compared with similar views of that later date in the study of proper motions.

Since there were no facilities on the mountain for the very necessary evening meal, Stanford University substituted box suppers, the Peninsula society conveying them to the observatory. We were joined by the observatory staff and their families in an informal picnic supper in the shadows of the 12-inch and 36-inch telescope housings. Dr. Shane, as host, provided coffee and ice cream.

Promptly at the appointed hour we were treated to a brilliant sunset — a memorable display. There was considerable light cloudiness in the late afternoon, but soon after sunset the skies cleared and the last visitors did not complete their observing through the Lick refractors until midnight. At last year's convention in Los Angeles a small group, led by Walter H. Haas, editor of *The Strolling Astronomer,* sketched their impressions of Ganymede, Jupiter III, using the Griffith 12-inch refractor, as described in *Sky and Telescope,* January, 1950, page 59. This year these observers were allotted time for similar sketching, using the 36-inch refractor at 740 power on the same object. Comparison will be very interesting.

The convention was highly successful in its aims of educational and social contacts among western amateur astronomers, and in the assurance of future gatherings. Minutes of the convention will be published, and information may be obtained from the Peninsula Astronomical Society, c/o Mrs. Dorothy Rossiter, 922 Roble Ave., Menlo Park, Calif.





(Left) The 1/16 scale model of Lick Observatory's 120-inch reflector (pictured on the front cover of "Sky and Telescope" for January, 1947), is here placed in a skeleton model of the building and rotating dome, showing arrangement of the working area on the second floor.

(Right) The observer at the Newtonian prime focus will ride in a cage (as with the 200-inch), of which a full-sized mockup is shown here, with a portion of its housing removed. In cross-section it measures 32 by 48 inches, and it is 70 inches high.

Lick Observatory photographs.

Amateur Astronomers

NORTHWEST REGIONAL CONVENTION IS HELD

THE THIRD annual convention of the Northwest region of the Astronomical League was held at the Pacific Power and Light Company auditorium in Yakima, Wash., on Saturday and Sunday, July 29-30. The Yakima Amateur Astronomers was the host society, and an account of the convention is given in their publication, *The Observer*, for August, together with a list of the papers and a partial list of the exhibits. It is stated:

"The highlight of the convention was the exhibit of meteoritic material brought to Yakima for the occasion by Harry G. Johnson of the Brown Foundation of Walla Walla. Part of the famous Nininger collections at Meteor Crater, Arizona, the meteorites attracted a great deal of attention. Mr. Johnson gave a lecture on the subject Saturday evening and reviewed the history of many of the specimens."

The newly elected officers of the region are: Clinton A. Wood, Portland, chairman; Darold M. Hughey, Yakima, vice-chairman; Norman C. Smale, Portland, recording secretary; Charles G. Benson, Portland, executive secretary; Edward V. Lockhart, Jr., Yakima, treasurer; Edward J. Newman, Yakima, league council representative.

Carl P. Richards, vice-president of the league, gave a report on the Wellesley convention, where he represented the region and its societies. About 40 persons attended the convention banquet, and all present introduced themselves. Miniature telescopes containing black-and-white transparencies of the moon were awarded winners of a "scrambled astronomy" contest.

NEW YORK AAA OPENS 24th SEASON

With a full program of activities, the New York Amateur Astronomers Association is beginning the 1950-51 season, the 24th of its existence. Classes in elementary, intermediate, and advanced astronomy, each meeting weekly, will be under the direction of W. Wallace Benjamin, Samuel C. Silver, and Gonzalo Segura, Jr., respectively. The home study course for members unable to attend regular meetings is again being conducted by Aileen A. Pindar. Telescope classes in the optical division workshop will start the middle of October and continue for 20 weekly sessions.

Regular lecture meetings, special field trips, and a weekly observing meeting are also scheduled. Headquarters of the association are in the American Museum of Natural History, and further information may be had from Jane S. Davis, assistant secretary, Amateur Astronomers Association, American Museum, New York 24.

THIS MONTH'S MEETINGS

Boston, Mass.: The Bond Astronomical Club will meet Thursday, October 5th, at the Little Planetarium, Boston Museum of Science, Science Park, at 8:00 p.m.

Chicago, Ill.: The Burnham Astronomical Society will meet on Sunday, October 8th, at 2:30 p.m. in the lecture hall of the Adler Planetarium. Dr. Thornton Page, of Yerkes and McDonald Observatories, will talk on "The Nebulae." Meetings will be at the planetarium while the society's regular lecture hall is temporarily closed for repairs.

Dallas, Tex.: Chester A. Howard will speak on "Curiosities of the Sky" at the October 23rd meeting of the Texas Astronomical Society, in the community room of the Texas Bank and Trust Co. at 8 o'clock.

Geneva, Ill.: The Fox Valley Astronomical Society will meet at the Adler Planetarium in Chicago on Tuesday, October 10th, at 8:00 p.m. Book reviews will be presented by Frank Hancock. A model illustrating the precession of the equinoxes, by Ludwig Grandl, will be demonstrated, and Wagner Schlesinger, director of the Adler Planetarium, will use the Zeiss instrument to show the causes and effects of precession.

Indianapolis, Ind.: Meeting at Cropsey Hall in the Riley Library, the Indiana Astronomical Society will hear a review of the lunar eclipse, presented by the board of officers, at its October 1st meeting, 2:15 p.m.

Kalamazoo, Mich.: "Astronomy's Contributions to Civilization" will be discussed by Spencer Van Valkenburgh at the October 7th meeting of the Kalamazoo Amateur Astronomical Association, at the home of Mr. and Mrs. D. C. Lawrence, 819 Worden, Comstock, Mich.

Madison, Wis.: On October 11th the Madison Astronomical Society will hold its annual banquet at the Memorial Union. A moving picture of the Mexican volcano Paricutin will be shown, and there will be discussion of the new Washburn Observatory telescope.

New York, N. Y.: Robert R. Coles, acting chairman of the Hayden Planetarium, will speak on "Science and Popular Hoaxes," at the October 4th meeting of the Amateur Astronomers Association, 8 o'clock in the lecture hall of the Roosevelt Memorial building, American Museum of Natural History.

Washington, D. C.: The National Capital Astronomers will meet on Saturday, October 7th, at 8:00 p.m. in the Commerce Building auditorium. Dr. L. L. Rice, former president of Cumberland University, will speak about "Our Mysterious Universe."

JUNIOR ASTRONOMERS

A new astronomical society has been formed by a group of interested juniors in Columbus, Ohio, writes Frank P. Hudnall, of 281 Rosslyn Ave., Worthington. The first meeting of the Junior Columbus Astronomical Society was on August 8th, and in September the group visited the McMillin Observatory and planetarium. There are 15 members at present, and the society will welcome suggestions, hints, and help, as it is quite new and inexperienced.

Officers, "as an innovation," are: **Ursa Major,** Judy Smith; **Ursa Minor,** Patty Boggs; **Cassiopeia,** Sally Taylor; **Leo,** Gay Orthoefer; **Libra,** Marla Hoskey.

Another organization has recently become a junior member of the Astronomical League. The Junior Astronomy Club of the Ft. Worth Children's Museum, 1306 Summit Ave., Ft. Worth 4, Tex., has about 20 members at present. Instructor and correspondent is Miss Charlie M. Noble.

THE LIFE OF AN ASTRONOMER

ONCE upon a time, in the Tropic of (1), to poor but honest parents was born a (2). From the beginning, it was apparent that someday he would be a genius of the first (3). "We shall name him (4)," said his father, "and we must see that nothing (5) his character and ability."

While an infant, he was dressed simply, and usually went barefoot, having no (6). As a child, he ate heartily and drank his milk from a (7). Soon he grew as strong as (8), and had to go to school where he learned a whole (9) of subjects. He studied grammar, especially (10).

In the summer, when the (11) was high, he liked nothing better than to go fishing with his (12). He was quite light-hearted and wished for the wings of (13) so that he might fly through the sky. But, as he grew up, he became less carefree and more (14). He was very proud of the first (15) he earned. He studied hard and eventually reached the (16) of his career. Many scholars gathered in (17) around him, and he met with little or no (18). He occupied the highest position of eminence, thus being to his fellow workers what (19) was to the Roman gods.

One day he met the girl of his dreams, whose name was (20). They were married, went on a honey (21), and lived happily ever after, with nothing to (22) the brightness of their smiling faces.

JOANNA OVERN
Madison Astronomical Society

(Answers on page 297)

METEORS IN OCTOBER

One of the more reliable meteor showers may be favorably observed in October. The Orionids are at maximum on the 19th and 20th, and may be seen to a lesser extent from October 15th to 25th. The moon is not unfavorable, first quarter occurring on the 18th, and the moon is situated in Capricornus, 120° from the radiant, on the 20th. The British Astronomical Association gives the hourly rates as 12 under good conditions. Best observations of meteors are generally made after midnight. Orionid meteors are swift, radiating from multiple centers about 10° northeast of Betelgeuse.

The Taurids, a lesser known shower, begin about October 26th, reaching maximum from November 3rd to 10th. Rates are low, but serious observers should record meteors from this shower. The radiant is at $3^h\ 40^m$, $+15°$, or 10° south of the Pleiades.

E.O.

Some Stars of High Velocity

By Otto Struve, *University of California, Berkeley*

More than 200 years have elapsed since Edmond Halley discovered the existence of proper motions among the "fixed" stars. From a comparison of positions determined by Tycho Brahe (16th century) and those listed in Ptolemy's *Almagest* (2nd century), he found that Sirius, Procyon, and Arcturus had changed their apparent positions among the more distant, faint stars of their surroundings. He concluded that other stars would probably show similar motions on the celestial sphere.

Since then the study of the proper motions of the stars has become one of the most important activities at several observatories, and at the present time our catalogues contain the angular motions of approximately 200,000 stars. The largest apparent motion of all belongs to the faint star discovered many years ago by E. E. Barnard: it amounts to 10.3 seconds of arc per year. Since even with a small telescope we can separate double stars whose distances apart are less than one second, it is easy to detect the motion of Barnard's star from observations separated by a week or two!

The reader is referred to the Sproul Observatory article in the June, 1950, issue of *Sky and Telescope* for the evidence by which we determine that Barnard's star has a motion in the plane of the sky at an actual speed of about 92 kilometers per second. As described there, however, the *space motion* of a star contains another component, the radial velocity, measured directly from the Doppler displacements of the lines in the star's spectrum. Barnard's star has a speed of approach of 110 kilometers per second. The space motion can be computed by solving the rectangular triangle whose sides are 92 and 110; the result is 143 kilometers per second. As the direction of the proper motion is also observed on the celestial sphere, we can define the space motion not only as to amount, but as to direction.

Space motion is referred to the solar system as its standard of rest. In other words, the measured motion is composed of the motion of the star and that of the sun, within the larger framework of our galaxy. Most of the brighter stars whose motions through space have been measured have linear velocities of the order of 10 to 20 kilometers per second. But there are other stars whose space velocities exceed even that of Barnard's star: values up to 500 kilometers per second, and even more, have been definitely established.

It is with some of these stars of high velocity that we shall concern ourselves this month. The impetus was a paper in a recent issue of the *Zeitschrift für Astrophysik*, by W. Lohmann, who investigated the motions of a remarkable and puzzling group of high-velocity stars — the subdwarfs. They were first recorded at the Mount Wilson Observatory by W. S. Adams and others, who found several objects which in the Hertzsprung-Russell diagram occupy a position intermediate between the white dwarfs and the main sequence. They designated them provisionally as "intermediate white dwarfs." A few years later, G. P. Kuiper noticed that there is an entire sequence of stars below the main sequence and approximately parallel to it, and he suggested that we call it the subdwarf sequence. He also called attention to the remarkable fact that almost all subdwarfs are high-velocity stars.

Their spectra are different from those of ordinary dwarfs. According to A. H. Joy, the absorption lines are unusually weak and indistinct, although they are fairly narrow and cannot be explained as the result of fast axial rotation. Most recently, O. J. Eggen has determined the position of the subdwarf sequence accurately within the H-R diagram, by means of photoelectric color determinations combined with the known absolute luminosities of these stars.

It should be pointed out that all known subdwarfs are relatively close to us. They are intrinsically faint stars — fainter than the ordinary dwarfs — and even when the apparent magnitude is 12, they are rarely farther away from us than 100 parsecs (325 light-years). We can regard them as true neighbors of our sun in space. Of course, that does not mean that there are no subdwarfs elsewhere in the galaxy. It simply means that the very distant subdwarfs are too faint and their angular proper motions too small to measure with our present methods.

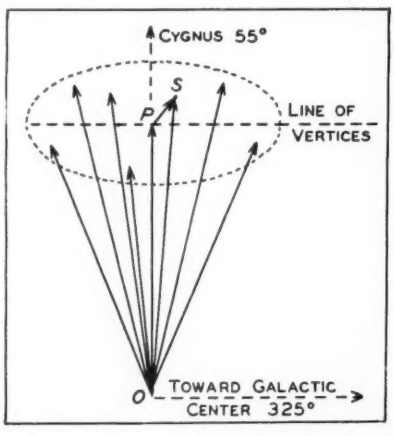


Fig. 1. The manner in which slight deviations from circular revolution produce apparent preferential stellar motions along the line of vertices.

We have already referred to the motions of the brighter stars. These are, in the majority, also neighbors of the sun. Together with the sun they form a swarm whose centroid moves at right angles to the direction of the galactic center. Since the sun is a member of this swarm, we cannot measure the circular motion of galactic rotation by observing other members of the same swarm. We require as reference points some objects that do not participate in the galactic rotation. N. U. Mayall's radial velocity measurements of the globular clusters furnish the required system; the local swarm of stars has a velocity around the galactic nucleus of the order of 275 kilometers per second.

Within the swarm the stars appear, at first sight, to move at random, like the individual mosquitoes in a swarm of such insects which, as a whole, is carried by the wind. As a result of our own motion within the swarm, the other members of the swarm appear to approach us if we observe in the direction of Hercules and to recede if we observe in the opposite direction of the sky, in the constellation Lepus. This is the solar motion, about 20 kilometers per second with respect to the centroid of the swarm, roughly in the direction of the star Vega.

After we correct all observed star motions for the effect of the solar motion, the remaining "residual space velocities" of the stars are obtained. But even these are not distributed entirely at random. It looks as though the stars locally prefer to move in a certain direction — the *line of vertices* — which is directed toward and away from the galactic center.

Let us make a diagram to illustrate the phenomenon of stellar motions, Fig. 1. In doing so we must clearly understand that we are not attempting to show a picture of the galaxy or any part of it. What we shall do is produce a graphical representation of the velocities, in amount and direction. The plane of the paper is the central plane of the Milky Way; point *O* is the center of our diagram's co-ordinates, and the direction toward the galactic center, at galactic longitude 325°, is to the right. Then the circular velocity of galactic rotation will be at right angles to this

line, in longitude 325° + 90° = 55°. Let an arrow *OP* represent this circular motion of 275 kilometers per second. The sun's small motion with respect to the centroid of our swarm of stars is designated by the arrow *PS*. Then, it is clear that the arrow *OS* defines the amount and direction of the sun's motion with respect to the galaxy as a whole. The rest of the stars of our swarm also have individual motions which depart slightly from that of pure circular motion, *OP*. If we plot them in our diagram we obtain a narrow bundle of arrows starting from *O* and ending in a roughly elliptical area, whose long dimension is the line of vertices, parallel to the direction of the galactic center.

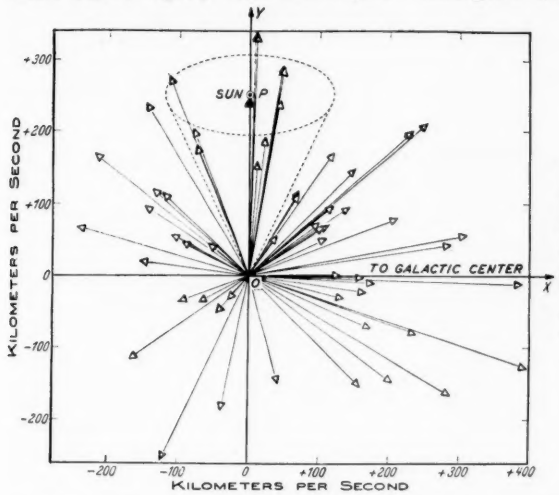


Fig. 2. Lohmann's plot of the space motions of 59 yellow and red subdwarfs, which in general differ very much from that of the sun. About one third of the orbits are retrograde; these lie in the lower part of the diagram.

This effect of motion along the line of vertices was discovered before galactic rotation was proven. K. Schwarzschild long ago described it in his ellipsoidal theory of stellar motions, suggesting that the stars behave like vehicles on a broad highway, moving preferentially along the highway, and not so often across it. Now, however, we see that the actual principal motion is that of the stars around the galactic center, and the motions of the stars along Schwarzschild's highway are merely a result of their slightly differing paths around the galactic center, even the sun itself departing from true circular motion. The line of vertices is being carried around the galactic center just as a highway on the earth is carried around the earth's center at speeds over 10 times faster than those of the vehicles along the highway itself. For the normal stars in the sun's neighborhood, this rough ratio also holds when the local motions along the line of vertices are compared with those of circular galactic rotation.

An entirely different picture is obtained if we plot, with Lohmann, the motions of 59 yellow and red subdwarfs. Fig. 2 is taken from his paper and is similar to Fig. 1. The oval-shaped area surrounding the point *P* (or the sun) is that defined by the arrows of the local swarm. We see that the subdwarfs cover the entire area of the diagram and are not restricted to the small area around the sun. But about two thirds of the arrows end in the upper portion of the diagram: they lie above the point *O*, and only one third are lower.

How are we to interpret these results? We shall make use of a clever nomogram which was first constructed by the brilliant German astrophysicist, K. F. Bottlinger, whose early death, before World War II, has deprived science of one of its most productive workers.

It can easily be shown by means of the simple formulae of celestial mechanics that if the velocity of a star differs from that of circular motion in direction, the corresponding orbit is elliptical; and if it also differs in amount, the semimajor axis of the ellipse differs from the radius of the circular motion. We need not go into the details here, but shall simply accept Bottlinger's nomogram as a convenient working tool. In Fig. 3 we find a series of circles and a series of approximately oval-shaped curves. The former are labeled *a*, designating the semimajor axis of the galactic orbit of any given star, in units of the distance between the sun and the galactic center, considered to be 8,000 parsecs. The ovals are labeled *e* and show the eccentricities of the orbits. Take a sample arrow from Lohmann's diagram and plot it in Fig. 3. The end of the arrow may fall close to the circle for $a = 0.57$ and to the oval for $e = 0.8$. The orbit of such a star is thus highly elongated and its semimajor axis is only slightly greater than 4,000 parsecs. Yet at the present time the star is in our immediate vicinity. It must be close to the *apogalacticon* of its elliptical orbit (corresponding to aphelion of a planetary orbit).

All points above *O* have direct orbits. Those below, however, have retrograde orbits; their motions are directed opposite to that normally regarded as the direction of galactic rotation. As already mentioned, according to Fig. 2 about one third of the subdwarfs appear to have retrograde orbits.

For completeness, we must point out that Bottlinger's nomogram is based upon the assumption that the force of attraction of the galaxy is all concentrated at its center. This is not entirely correct: The stars in our neighborhood exert perturbations upon individual stars, and the nucleus of our galaxy is not a geometrical point, but occupies a fairly large volume. Nevertheless, as an approximation to the truth, Bottlinger's procedure is very useful. It shows, for example, that any point that falls outside the limiting circle $a = \infty$, $e = 1.0$, corresponds to a hyperbolic orbit. Such a star will leave our galaxy for good and will become an intergalactic wanderer.

The fact that few arrows in Fig. 2 end within the oval around the sun shows that subdwarfs have, as a rule, highly elliptical orbits. They actually dip into the nucleus of the galaxy (see diagram, page 132, *Sky and Telescope*,

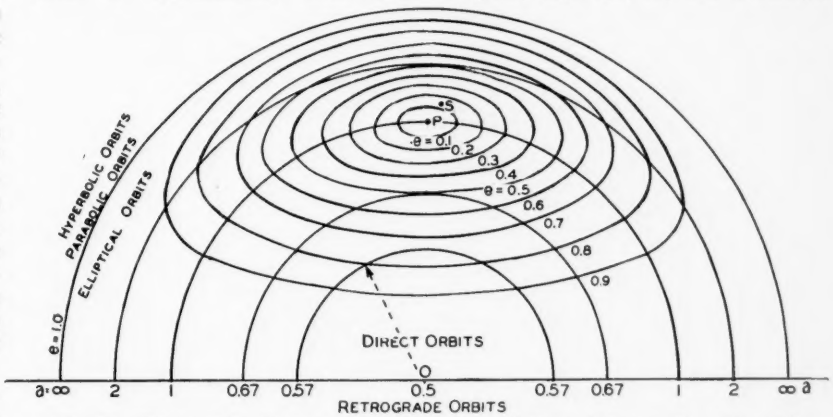


Fig. 3. Bottlinger's diagram containing the relations between the size and shape (semimajor axis and eccentricity) of a star's galactic orbit and its observed space motion in the vicinity of the sun. The sun's vector falls at S, where the eccentricity is about 0.1, and the semimajor axis about 1.3 units of 8,000 parsecs.

April, 1950), and they are doubtless perturbed inside that dense region of stars in such a way as to produce a rosetta-shaped pattern of orbits, each individual loop of which resembles a Kepler orbit. A high-velocity star, once it has left our region of space, will never exactly come back to it.

More interesting is the idea that the subdwarfs may actually have originated in the central regions of the Milky Way. Perturbations by passing stars may have resulted in elongating their orbits to the extent needed in order to let them reach the vicinity of the sun. This problem is in some respects analogous to that of the comets described in the February, 1950, issue (page 82), and the methods applied to the comets may well give useful results in connection with the motions of the stars.

Thus, the subdwarfs appear to be temporary visitors in our "local swimming hole" of the universe, and their true home is the nucleus of the galaxy. But, like the man who came to dinner, they spend a quite unreasonable fraction of their lives imposing upon the hospitality of the sun and its companions, and they return to their legitimate residence only for the briefest of intervals — unless, of course, some angry nucleus star comes along and again distorts their orbits in such a manner as to compel them to stay closer to their home.

Incidentally, the high-velocity stars investigated by Lohmann also have large orbital inclinations, in contrast to the members of the solar swarm, which are more nearly constrained to the plane of the Milky Way. Fig. 4 is a diagram drawn in the same manner as Fig. 2, but oriented in the plane perpendicular to that of the galaxy. The motions show a slight preference for the central line *OY* in which the plane of the galaxy cuts the plane of the paper, but there are plenty of stars with orbits that are highly inclined. It is probable that the subdwarfs form one of the spherical subsystems of the galaxy discussed in the May issue.

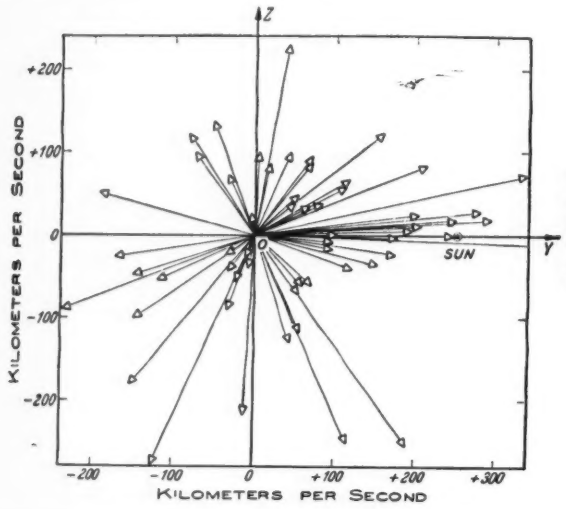


Fig. 4. The motions at right angles to the galactic plane of the same 59 yellow and red subdwarfs plotted in Fig. 2, according to Lohmann.

AUGUST AURORAL DISPLAYS ARE WIDELY OBSERVED

SIX reports have been received on the display of northern lights that occurred in the period August 18-20, seen over the widespread region of the eastern United States and Canada indicated by the following summaries.

Boyce Holoman, c/o Boylan-Pearce, Inc., Raleigh, N. C., observed a display already in progress at 12:45 a.m. EST, August 20th, from Kitty Hawk, N. C. The aurora extended from about 56° west of north to about 36° east of north and from 10° to 20° above the horizon. The lighted area, whitish blue with a tinge of green, was wedge-shaped, widest at its western end, and split across its center by a dark lane running west and east. Rays and brighter spots could be seen along the bright bands. A heavy sea mist at the time prevented observation of the stars, except that Jupiter and a few 1st-magnitude stars overhead occasionally showed as hazy blobs. A strong north-northeast wind, 30 to 40 miles per hour, may have helped make the aurora so easily visible. At 3:30 a.m. the aurora faded away. Later that day hurricane No. 1 of the 1950 season passed to the east of Kitty Hawk.

Carl H. Gamble, 3201 Coaltown Road, Moline, Ill., reports from his Skyridge Observatory observing aurorae on two successive nights: August 18, 9:15 to 9:45 p.m. CST, fairly luminous auroral cloud in the vicinity of Ursa Major gradually moving to the west. The next night, a very active display began at 8:00 p.m., lasted for four hours, and there was more activity observed at 1:20 a.m. August 20th, with the landscape as bright as with the moon in the quarter phase. The high point of this display occurred about 9:50 p.m. August 19th, when the entire sky was covered with rayed bands, even as far south as Sagittarius. These met to form a corona at a point between Vega and Altair, and at 10:30 this was very brilliant with rapid pulsations. In the entire display there was very little color, only occasionally a pale green.

Elsewhere in Illinois the display was also observed. F. A. Keysor, 415 N. Ashland Ave., LaGrange, and Carl Bertram, 5154 W. Parker, Chicago, sent in short accounts of the display between 9:00 and 10:00 p.m. August 19th. At this time also, Robert Lee Swope, 224 Ordnance Court, Burlington, Iowa, saw "the most magnificent and unusual display of northern lights I have yet observed." He and Mr. Bertram remarked on the intensity of the coronal aurora.

From Toronto, Ontario, where aurorae are more common occurrences, E. V. Greenwood, 454 Willard Ave., writes: "The night of August 19-20 will be remembered for a long time by amateur astronomers in Ontario. A brilliant display of northern lights was seen from practically all regions of the province. From Cochrane and Moosonee in the north reports say the display was the best seen in many years." Mr. Greenwood first saw the display himself about 10:30 p.m., and it lasted until well after midnight. At times the whole sky was filled with the shimmering, darting forms.

In response to an informal request, Neal J. Heines, president of the American Association of Variable Star Observers and chairman of its solar division, states that August 18-21 was the most active period of the month on the sun. Sunspot counts were low as compared to those at maximum of solar activity, but not lower than those to be expected at this time of the cycle. An active group of spots in the central zone of the sun at that time had rapid development.

Other bright aurorae have been reported during the past few months. Paul A. Smith, 122 E. North St., Geneseo, Ill., saw a display on June 5-6. Edgar M. Paulton, 624 Madison Ave., New York 22, N. Y., writes of a magnificent display on August 7th, seen from Sharon, Conn. He submitted a sketch of the coronal part of the display, but space does not permit its publication here.

THICK EMULSIONS

Ordinary photographic plates "catch" cosmic ray tracks as the particles pass through the emulsion. But the emulsions are so thin that much valuable information is necessarily lost.

Hence, Dr. Herman Yagoda, of the National Institutes of Health at Bethesda, Md., has been using very thick emulsions without the usual supporting glass plate. The emulsion is cast in blocks two inches in diameter and a quarter-inch thick. Before exposure all water is removed from the silver-bromide and gelatin mixture so that the thickness is 1/10 inch. Science Service reports that these emulsions have been found thick enough to give improved pictures of double nuclear collisions and for following the whole slowing-down and stopping process of fast particles.

NEWS NOTES

By Dorrit Hoffleit

COOKING YLEM

"If there is a simple curve there must be a simple explanation" is what George Gamow is quoted as saying in regard to observations on the abundances of the elements in the universe. In the August *Physics Today* he discusses the "brew" from which the present atomic species must have emerged. He finds that *ylem*, the primordial mass of original neutrons, protons, and electrons that existed during the first few hundred seconds of the history of the universe, must have had a temperature of a few billion degrees. As this mass began its present continuing expansion the temperature dropped and elements began to form. Deuterons, heavy hydrogen nuclei, formed first, followed by the light isotopes of helium. The absence of an element of atomic weight 5 is still a puzzle, perhaps associated with a once-existent carbon 10.

Heavier elements could grow exclusively by the capture of free neutrons; their capture cross-sections increase exponentially up to atomic weight 100 and then remain constant for heavier elements. The heavier elements are at present so few relative to hydrogen and helium that the atom-building process must have practically ceased only half an hour after it began. By that time the universe had expanded to a point where the collisions between particles became too few for further atom building. The mean density during the formation process must have been about 10^{-9} grams per cubic centimeter.

Dr. Gamow points out that the expansion of the universe began a few billion years ago, and that while it is slowing down it will never stop: "Our universe is expanding limitlessly into the infinity." The original nuclear density of 10^{14} grams per cubic centimeter has become 10^{-30} grams per cubic centimeter, corresponding to an expansion of 500 trillion times.

COSMONAUTICS

With a speed about one third that of light a rocket should be able to make a round trip to our neighbor, Alpha Centauri, in 26 years. Guido von Pirquet, in the *Journal* of the British Interplanetary Society for July, goes beyond the solar system to speculate on the dangers of interstellar travel in rockets with atomic fuel, the "great ideal of cosmonautics."

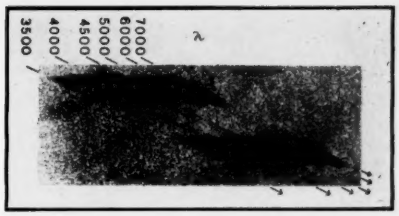
He agrees with others in dispensing with any danger of the destruction of spaceships by meteorite hits within the solar system, but points out that the interstellar rocket in one second would pass through a space 3,000 times that traversed by an ordinary rocket, and he alters a table of hits per hour to hits per second. Assuming a frontal area for the rocket of 100 square meters, particles only about 10 microns in diameter (corresponding to 22nd-magnitude meteors) would collide with the rocket about three times a second.

Their damaging power, proportional to the square of the rocket's velocity, would be 10 million times greater than to a slow-moving interplanetary rocket, and they would destroy the rocket's skin much faster than any hypothetical repairman could fix it. Furthermore, meteors of 14th-magnitude size would contribute three hits per hour, and zero magnitude three hits per year. These would certainly be disastrous, even were an interstellar rocket otherwise to become possible.

SPECTRUM OF A METEOR TRAIN

In a letter to *Nature* magazine, Dr. Peter M. Millman, of the Dominion Observatory at Ottawa, describes the first photographic spectrum obtained of a meteor train. A bright meteor may leave in its path a faint enduring luminosity known as the *persistent train.* Visual observers in the 19th century had identified the yellow sodium and the green magnesium lines in meteor trains, and these are confirmed in the photographic spectrum of a Perseid meteor train in which lines of neutral iron and calcium were also found.

The meteor was observed on August 13, 1949, at 3:20 UT, during the cooperative program of meteor observing by the Dominion Observatory and the National Research Council at Ottawa. The meteor appeared blue, was very bright at magnitude −4 (about as bright as Venus), and had a train which remained visible in the bright moonlight for 11 seconds. The radar echo on 30 megacycles lasted for 110 seconds.



The spectrum of the persistent train of a Perseid meteor is seen here between two segments of the spectrum of the meteor itself. The very faint train lines (dark on the negative reproduction) can best be seen by looking along their length, holding the page at an angle. The meteor moved in the direction of the arrows. Dominion Observatory photograph.

The spectrum was caught on Eastman 103aF emulsion with a dispersion of 450 angstroms per millimeter at the hydrogen-gamma line. A rotating shutter eclipsed the lens 10 times per second for twice as long as it was exposed. As the meteor head was moving rapidly, its spectrum appeared as a series of short bright segments. Between these, not moving, the enduring train recorded itself as a few bright lines.

In the spectrum of the meteor itself, Dr. Millman found about 40 lines due to neutral iron, calcium, magnesium, and sodium, as well as to ionized calcium, magnesium, and silicon. The lines corresponding to the ionized elements became stronger toward the end of the path. In the train, however, there was a complete absence of lines due to ionized elements, whereas the lines of neutral magnesium and calcium and those iron lines arising from transitions to levels higher than the ground state of the atom were relatively enhanced in the spectrum of the train.

"Both these features," notes Dr. Millman, "lend support to the hypothesis that the luminosity of the train is a recombination spectrum involving chiefly the elements common in the light of the meteor."

The height of the train is estimated at from 85 to 70 kilometers above sea level, with the brightest part of the train at 83 kilometers, near the lower limit of the mean height range of luminous meteor trains observed at night, and very close to the mean height reported for noctilucent clouds.

In the CURRENT JOURNALS

POWER FROM THE SUN, by Eugene Ayres, **Scientific American,** August, 1950. What are the fundamental means of tapping the bounteous supply of energy showered upon the earth by the sun?

RADIO OBSERVATION OF METEORS, by Oswald G. Villard, Jr., **Leaflet** No. 256, of the Astronomical Society of the Pacific, August, 1950. "Now that we know how easily it may be done, the surprising thing is that meteor reflections remained unexploited for so long."

PERTURBATIONS OF A SATELLITE ORBIT, by Lyman Spitzer, Jr., **Journal** of the British Interplanetary Society, May, 1950. It is shown that the motion of a small body revolving in a nearly circular orbit around the earth at about 800 kilometers above the surface is perturbed by the oblateness of the earth more than by the sun and moon.

ANSWERS TO THE LIFE OF AN ASTRONOMER

(Story on page 293)

1. Cancer; 2. sun; 3. magnitude; 4. Leo; 5. Mars; 6. Bootes; 7. Big or Little Dipper; 8. Hercules; 9. Ceres; 10. conjunctions; 11. Mercury; 12. pole; 13. Pegasus; 14. Sirius; 15. quarter; 16. zenith; 17. clusters; 18. opposition; 19. Jupiter; 20. Mira or Norma; 21. moon; 22. eclipse.

The Amateur Astronomer as a Community Teacher -- II

By George W. Michalec

AS A GUIDE to those who may be interested in conducting their own astronomy classes, an adaptation of the course outline for the writer's class in the Pleasantville Adult School is given here. It is arbitrarily divided into 16 parts, each requiring approximately 1½ to two hours of lecture time. The time, too, is an arbitrary figure depending upon the length of the course. In practice, the indoor lecture has been interrupted for outdoor telescopic observing as frequently as weather permitted. Together with observing, this material can be conveniently covered in about 20 two-hour meetings.

In preparing lectures, it is best to standardize upon one or two reputable astronomy texts and to use others only as fill-in material. There isn't sufficient time to survey more texts if one is to meet weekly class commitments with reasonable preparation. Using such well-known sources as *Astronomy,* by Russell, Dugan and Stewart, and/or the Harvard Books on Astronomy offers a firm foundation. The instructor should follow current astronomical developments by reviewing *Sky and Telescope, Scientific American,* and other publications.

Preparation of lecture notes is, of course, a personal matter. The novice instructor should prepare thoroughly, possibly writing out the entire lecture. A rough estimate is three or four hours of preparatory time for one hour of class lecture. Of course, this heavy ratio is only for the first run of the class. Later repeats will require much less time since the only necessary work will be review, reorganization of, material, and additions.

A model of Mr. Michalec's 6-inch reflector used for classroom instruction.

Regardless of the form of the instructor's lecture notes, the writer strongly advises the compiling and distribution of condensed notes for the students. The extra work and mimeograph cost is repaid in benefit to the class. The notes should be condensations of the lectures but not so complete as to make class attendance unnecessary. They should merely free the student from trying to jot down important information while listening to the lecture.

Ideally, a class text would be the best source material, but an expensive text may turn away some of the interested public for financial reasons as well as for possible dislike of such a formal treatment of the course. The instructor's inexpensive condensed notes have neither of the above limitations. The writer distributes about 40 typewritten pages, which constitute a handy course syllabus.

Certain facts are usually easier to grasp and remember permanently when grouped into logical listings and tables, which should also be distributed. A solar system table can give for the planets and their satellites the dimensions, densities, surface gravities, periods, and the like. A list of the 20 brightest stars with their distances and absolute magnitudes is revealing. Another helpful list is stars of typical spectral classes, including their magnitudes, surface temperatures, diameters, masses, and densities.

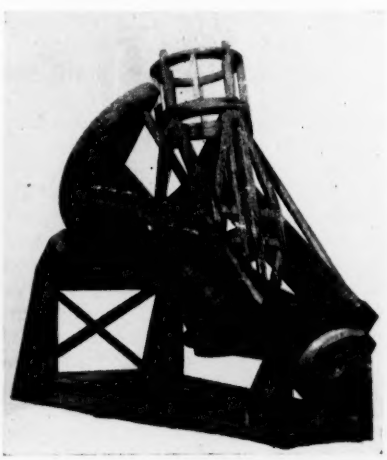
Inexpensive or free astronomical notes and charts include the Maryland Academy of Sciences' annual Graphic Time Table of the Heavens, and the *Observer's Handbook* of the Royal Astronomical Society of Canada. A complete reference list is essential, including reading material for persons of all ages. Often in an adult class the parents like to know what books would be suitable for introducing the subject to their young children. In a small community, the instructor should visit the public and school libraries and base the reference list upon the material available.

A novel way to open the course is to surprise the class with a short quiz. The students will not object if you assure them the purpose is not to embarrass them but to determine their backgrounds. The results are usually very revealing. The writer's quizzes have been printed on one page containing 20 questions requiring mainly one- or two-word answers. Typical general questions are: Is astrology an exact science? What are the distances to the moon, sun, and nearest star? What are sources of planet light and starlight? Usually the class turns in very poor results, which indicates the need for the course. The writer has used a satisfactory procedure of not returning the quiz papers until the conclusion of the course, at which time the class as a group goes over the quiz, realizing they now know answers to things which previously had been unmeaning and mystifying. The instructor also receives satisfaction, for the repeat quiz results are an indication of his teaching ability.

Use models and real equipment in the class. Models are fun to make, or they may in some instances be purchased or borrowed. Early in the course I usually demonstrate telescope mounts and manipulations with the aid of a small model of the same telescope which the class uses in later outdoor work. This overcomes the difficulty of studying the mounting in the darkness outdoors. The writer has constructed a small model of the 200-inch telescope, from which the students are able to see the similarity of mounting of all telescopes regardless of their sizes. Pictures of these two models are reproduced here.

Accessories such as cameras and spectroscopes are especially helpful. To demonstrate real spectra, I use a small inexpensive spectroscope and standard mercury, sodium, and tungsten incandescent lamps, as well as moonlight. This experiment is improved by large reproductions of actual spectra, particularly of those being viewed in the spectroscope. A very handy source of such material is the issue of *Life* on "Color," July 3, 1944.

Movies and slides on suitable astronomical topics can be obtained from various educational institutions and movie rental companies. I have obtained rental films and slides from the education department of the American



A model of the 200-inch telescope to ⅛-inch scale. Boyce Studio photos.

INTRODUCTION TO ASTRONOMY

I 1. *Introduction to astronomy.* Relation to other sciences, branches of astronomy, practical utility, value in education, public interest, philosophical value
2. *The earth's relationship to the astronomical family,* with a brief introduction to the various members of the universe (planets, solar system, stars, clusters, nebulae, and galaxies) which will be studied in greater detail in following lectures

II 3. *A brief survey of the astronomers' tools.* Telescopes, spectroscopes, photography
4. *Amateur telescope making*

III 5. *Astronomical systems of measurement*
a. The celestial sphere
b. Constellations, star designations, star brightnesses
c. Various times—sidereal, apparent, mean, civil
d. Linear distances — astronomical unit, light-year, parsec
e. Nautical almanac and ephemerides
6. *Celestial navigation* (very brief)

THE SOLAR SYSTEM

IV 1. *The earth as an astronomical body.* Physical nature, motion
V 2. *The sun,* in detail
3. *Eclipses*
VI 4. *The planets of our solar system,* in detail
VII 5. *Other members of the solar system.* Meteors, comets, asteroids
6. *Origin of the solar system*

THE STARS AND THE UNIVERSE

VIII 1. *The stars*
a. General. Distributions, numbers, magnitudes; motions of stars; use of stellar parallax to compute star distances
IX b. Stellar spectra. (1) Astronomical use of the spectroscope — theory of the spectroscope and the spectrum, practical demonstrations with a spectroscope, methods of obtaining stellar spectra. (2) The Draper classification
X c. The Russell-Hertzsprung diagram; application of the R-H diagram to compute stellar distances
XI d. Star clusters. Galactic clusters, globular clusters
e. Cepheid variable stars. How Cepheids aid in determining stellar distances
f. Double stars
g. Multiple stars
XII h. How stellar masses, diameters, temperatures, and densities are determined
XIII i. Variable stars
j. Novae and supernovae
k. Galactic nebulae
l. White dwarfs
m. General haze and interstellar gas
XIV 2. *The Milky Way system as an entity.* Number of stars, shape and size
3. *Theories as to origin and evolution of stars*
XV 4. *Galaxies.* Their number, nature, sizes, distances
5. *Supergalaxies*
6. *Future goals of astronomers*
XVI 7. *The nature and origin of starlight*
8. *Evolution of stars and the universe*

Museum of Natural History in New York City. The procurement of projection equipment is usually no problem if the course is being sponsored by the community public school system.

Helpful for class lecture work are reproduction photographs and charts. *Splendors of the Sky* and *Album of Celestial Photographs* (Sky Publishing Corporation), both inexpensive, are excellent for class use. Out-of-the-ordinary bits of material are good to use. A meteorite sample is impressive, and odd bits of optical elements, such as mirrors and prisms, are of interest.

Special guest speakers are of value. The speaker must be either a professional astronomer or an amateur with a specialty, including the designers and builders of professional and amateur astronomical equipment. The writer has successfully engaged an engineer who worked on the 200-inch Hale telescope — he presents a wonderful collection of photographs and personal experiences pertaining to the design and construction of the giant instrument.

Whenever possible, the course should include visits to observatories, planetariums, and astronomical meetings. Unfortunately, all of us are not situated adjacent to such facilities. However, don't quickly discard this item from your schedule before searching your neighboring area for a fellow amateur astronomer's observatory.

The work of organizing and teaching a course will be inspiring and enjoyable and will yield benefits to the instructor. Teaching experience is a valuable professional skill certainly worth acquiring. The amateur teacher will learn new things about astronomy in preparing the course.

Even though astronomy is a big thing in the lives of amateurs, we should realize it is still a small, specialized, unknown field to most of the public. Recognizing that most public education does not properly or adequately treat this subject, it remains for the amateur to answer this need by offering and leading in community astronomical teaching.

TERMINOLOGY TALKS

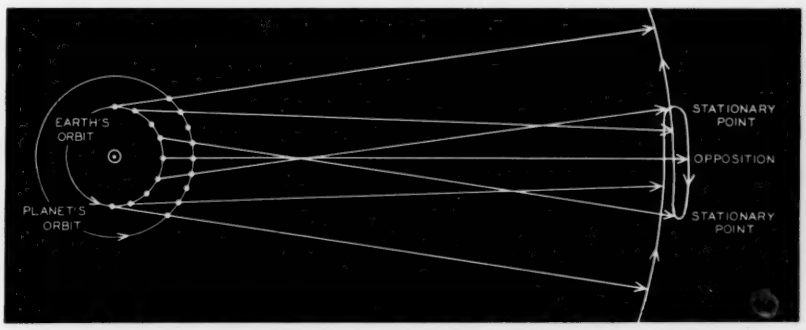
J. Hugh Pruett

Direct and Retrograde Motions

All the planets — even the thousands of tiny asteroids — revolve around the sun in the direction known as eastward, or counterclockwise as viewed from the north pole of the sky. But when we watch their apparent motions among the stars from night to night, we frequently get an entirely different impression. For a time they move as we believe they should; but then they apparently reverse and travel westward. For example, Jupiter at the beginning of this year was gaining about a minute in right ascension each day, in eastward motion. This daily motion continued for several months, but by May 13th had slowed to ½ minute daily. On June 28th, Jupiter stopped its previous motion and apparently began to move westward among the stars.

Such contrary motion confused the ancients who held to the geocentric (earth-centered) theory of the solar system. But the accompanying diagram shows the simple solution possible with the heliocentric (sun-centered) system. When the planet appears to move eastward with an increase in right ascension, its motion is said to be *direct*; when westward, *retrograde*. As it ceases its apparent motion in right ascension just before reversing, it is said to be *stationary*. This term in some almanac or astrological literature recently caused a correspondent to ask me, "Does the statement that Mars was stationary February 20th mean it actually stopped its motion in its orbit?" The planet, of course, always continues its orbital motion, but the apparent motion projected onto the background of fixed stars appears to stop. An examination of the diagram shows that opposition occurs at the middle of the retrograde motion.

Some motions in the solar system actually are retrograde. Many comets revolve from east to west, and a few planetary satellites have retrograde motions.



As the faster-moving earth passes a superior planet, our line of sight to that planet swings backward for a time to produce the apparent retrograde motion.

AMERICAN ASTRONOMERS REPORT

Here are highlights of some papers presented at the 83rd meeting of the American Astronomical Society at Bloomington, Indiana, in June. Complete abstracts will appear in the Astronomical Journal.

Improved Parallaxes

CURRENT Allegheny Observatory parallaxes have three times the accuracy of those determined more than 30 years ago. In 1914, photographic parallaxes were few, but under the direction of Frank Schlesinger, the new Thaw telescope, 46 feet long, turned out new values of star distances at a rapid pace. At that time 15 photographs spread over two or three years sufficed for each star. When parallax work took on a more leisurely pace, more photographs were used to obtain a star's distance. Under Heber D. Curtis, Schlesinger's successor, 30 photographs was set as a reasonable number.

The present director, Dr. N. E. Wagman, and Ellen Jameson have made a comparison of present and earlier values of Allegheny parallaxes. Naturally, in the early days the most important stars were measured first, and the value of redetermining their parallaxes is evident. Zaccheus Daniel has listed over 100 such stars on the Allegheny program. Twenty six of these are now finished, and they provided the material for the analysis of relative accuracies.

On the average the new observations comprise 33 plates for each star as against 15.6 for the old series. The magnitudes of comparison stars average 12.4 now, 10 formerly, and 4.8 comparison stars are measured instead of only 3.6. Another factor in improving the measures is the average exposure time of 194 seconds per plate, against 23 seconds in the early days.

Atmospheric Methane

IN THE INFRARED, the solar spectrum consists of approximately equal numbers of lines that originate in the sun's atmosphere and those that are absorbed by molecules in the earth's atmosphere. The latter are the telluric lines, and they provide useful information on the quantity and distribution of gases in the air as well as on temperatures and pressures.

The methane in the atmosphere over McMath-Hulbert Observatory at Lake Angelus, Mich., is equivalent to a layer 1.2 centimeters thick at normal surface temperature and pressure, according to observations reported by Dr. Leo Goldberg, of the University of Michigan Observatory. By comparison, it was found that over Mount Wilson Observatory the methane abundance is less by 10 or 20 per cent, which is just what would be expected at the higher altitude if the methane were uniformly mixed with the other atmospheric gases.

The thorough mixing is confirmed by observations of the telluric methane lines with the sun very close to the horizon. Dr. Goldberg extended the theory of previous workers, C. W. Allen and H. van de Hulst, to take into account the curvature of the atmosphere. If the methane were concentrated in a thin layer at some altitude, the line intensities near the horizon would be different from those actually observed.

A Peculiar Object

ON a 75-minute exposure with Harvard's Jewett Schmidt telescope a slightly fuzzy object surrounded by an almost perfect halo has been found in the constellation Serpens. It is located at $15^h\ 15^m.0$, $+21°\ 46'$, at galactic longitude 358°, latitude +54°. Arthur Hoag, of Harvard Observatory, pointed out that at first sight it seems to be a strikingly symmetrical planetary nebula.

But most planetaries are near the Milky Way plane, whereas this object is far from it; central stars of planetaries are, with one exception, among the bluest objects known, yet the nucleus in this case is reddish. In fact, the color is more like that of a galaxy, but there is no evidence of structure between the nucleus and the halo. The central image does appear to be diffuse, however, as verified with Harvard's 60-inch reflector in South Africa.

A star imbedded in a cloud of particles of a certain size might be surrounded by a halo of this sort, but no such effect has heretofore been observed in our dust-filled galaxy.

Another possible explanation is that two very distant galaxies are lined up exactly one behind the other, forming a "gravitational lens" system. According to the theory of relativity, light is deviated from its straight line path in the vicinity of massive bodies. The light of the halo, then, might originate from the more distant of the two galaxies, in the improbable event that such are being observed in this case.

The halo found by Arthur Hoag is only about 0.3 millimeter in diameter on the original Schmidt plate. Here it is enlarged, and in the reproduction the blank space between the halo and the fuzzy central object has become somewhat filled in. Harvard Observatory photograph.

Gas from Dust

HEATING of interstellar dust particles by hot stars may cause the evaporation of gas from the particles and the formation of the relatively dense emission nebulae often associated with such stars, according to Bertram Donn, of Wayne University. Photographs of emission nebulae such as the Orion nebula nearly always show associated dark clouds which would become the source of the gas.

At distances as great as one parsec from an *O*5 star and half a parsec from a *B*0 star, the temperature of interstellar grains would be about 50° absolute. These distances compare favorably with the dimensions of observed nebulae, and may be taken as the approximate limiting distances for evaporation. This would be the dominating process over such effects as radiation pressure and thermal diffusion of the gas.

Solar Variation

URANUS and Neptune shine by reflecting sunlight; thus each should reflect changes in the sun's brightness. Such changes may be measured directly, but variations in the transparency of the earth's atmosphere are unavoidably involved in the observations. Franklin E. Kameny, of Harvard College Observatory, has made use of the fact that the distance from the sun to Neptune to the earth is three light-hours longer than the distance from the sun to Uranus to the earth.

He made almost continuous photoelectric photometer tracings (interrupted for dark current, sky, and comparison star readings) on Uranus for three hours, followed by the same period on Neptune. The two independent tracings corresponded to the same three hours of solar radiation, and any significant short-period change in the sun's light should be shown similarly for each planet. However, no correlated fluctuations of periods several minutes to half an hour and greater in amplitude than 0.02 magnitude were found. Possible fluctuations of the order of an hour or more, and at or just below the limits imposed by instrument and atmosphere,

may exist but need further observation.

Uranus and Neptune were particularly suited to Mr. Kameny's observations, as their images are small enough to be compared with stars.

Ursa Major Cluster

IT IS well known that the five central stars of the Big Dipper have the same motion in space, and along with nine fainter stars form the nucleus of the Ursa Major cluster. Hertzsprung and others, noticing that Sirius and a number of other bright stars situated all over the sky had space motions quite similar to the nucleus stars, were led to believe that the Ursa Major cluster was of very large dimensions, the sun being located inside its boundaries.

Recent investigations by Daniel L. Harris, III, of Warner and Swasey Observatory, have demonstrated that the nucleus stars' space motion differs by a small but definite amount from the motion of Sirius. It is necessary to combine observations of radial velocities and trigonometric parallaxes with the directions of the proper motions to obtain the space motion of the nucleus. The solution represents all of the observed quantities in a satisfactory manner, and the contribution from each type of observation to the result is apparent.

The center of the nucleus is 82 light-years away. A preliminary examination of a number of stars in the extended Ursa Major group reveals only four stars, all within 70 light-years of the center of the nucleus, which the observations would indicate to be definitely members. The great majority of the group stars, such as Sirius, cannot be considered members; their space motions differ by more than one kilometer per second from the nucleus stars, which would amount to about 300 light-years in 100 million years.

T Tauri Variation

IT HAS BEEN suspected that dust and gas may be falling into the T Tauri dwarf stars from the dense clouds in which they are immersed. The low radiation pressure of dwarf stars fainter than the sun may permit such an infall. Dr. Jesse L. Greenstein, of Mount Wilson and Palomar Observatories, suggested that these stars may display phenomena visible in the solar chromosphere, but on a greatly enlarged scale.

Emission lines of hydrogen, helium, iron, ionized iron and calcium, and even ionized helium, observed in T Tauri spectra, could arise in a greatly expanded and denser chromosphere than the sun's. The irregular and sometimes rapid variation of light for which these stars are notable could be produced by phenomena similar to solar flares. Dr. Greenstein proposed that if the interstellar matter around such a star carries a magnetic field, originally of the order of 10^{-5} gauss, the field may become of the order of several gauss as the gas is compressed in its fall toward the star. If starspots exist, the moving magnetic field can then initiate flares near such spots. Solar flares show helium lines strong enough to be seen on the disk of the sun, and very intense flares have a continuous spectrum similar to that often occurring in the T Tauri variables.

Support for this general picture is found in the short-lived flareups of brightness that have been observed in several *M*-type dwarfs. One of the rare, small, intense solar flares visible in white light (not only in hydrogen light), if occurring on a faint *M* dwarf, could be as bright as the entire star, and thus cause a sudden doubling of its light. These outbursts may be weaker examples of the even stronger and perhaps continuous flares that occur in the T Tauri variables.

BOUND VOLUMES

We are closing out our stock of bound volumes at the cost price of $5.50 per volume postpaid. Only Volumes IV, V, and VI are available. These are for the years 1944-45, 1945-46, and 1946-47, respectively. Please remit with your order.

SKY PUBLISHING CORPORATION
Harvard Observatory, Cambridge 38, Mass.

For Bernhard Schmidt

More delicate than sight, more sensitive
Than touch, the lens is poised on Palomar
To take the message from the outmost star,
And sift the suns within the mirror sieve.

The light (but what is light?) that left its source
Those trillion years ago will leave its print
Upon this magic plate that caught its glint,
And draw the mind back o'er its arrow course.

The dream of man (and what is man?) has caught
The heavens and writ them here upon a glass:
Those distant galaxies may die and pass
But here they stay, transfixed by human thought.

The dreaming hand that drew the plans is dust,
There is no vision in the crumbled brain.
But what small triumph can dull death attain
O'er cosmos captured by the thought's sharp thrust?

CLARE SHIPMAN

Planetarium Notes

BALTIMORE: *Davis Planetarium.* Maryland Academy of Sciences, Enoch Pratt Library Building, 400 Cathedral St., Baltimore 1, Md., Mulberry 2370.

SCHEDULE: 4 p.m. Monday, Wednesday, and Friday; Thursday evening, 7:45, 8:30, 9:30 p.m. Admission free. Spitz projector. Director, Paul S. Watson.

BOSTON: *Little Planetarium.* Boston Museum of Science, Science Park, Boston 15, Mass. Richmond 2-1410.

SCHEDULE: Tuesday thru Friday at 3:30 p.m.; Saturday, 2:00 and 3:30 p.m.; Sunday, 3 and 4 p.m. Spitz projector. In charge, Charles A. Federer, Jr.

BUFFALO: *Buffalo Museum of Science Planetarium.* Humboldt Parkway, Buffalo, N. Y., GR-4100.

SCHEDULE: Sundays, 2:00 to 5:30 p.m. Admission free. Spitz projector. For special lectures address Elsworth Jaeger, director of education.

CHAPEL HILL: *Morehead Planetarium.* University of North Carolina, Chapel Hill, N.C.

SCHEDULE: Daily at 8:30 p.m.; Saturday and Sunday at 3:00 p.m. Zeiss projector. Director, Roy K. Marshall.

CHICAGO: *Adler Planetarium.* 900 E. Achsah Bond Drive, Chicago 5, Ill., Wabash 1428.

SCHEDULE: Mondays through Saturdays, 11 a.m. and 3 p.m.; Sundays, 2:30 and 3:30 p.m. Zeiss projector. Director, Wagner Schlesinger.

KANSAS CITY: *Kansas City Museum Planetarium.* 3218 Gladstone Blvd., Kansas City 1, Mo., Chestnut 2215.

SCHEDULE: Wednesday and Saturday, 3:30 p.m.; Sunday, 3:00 and 5:00 p.m. Spitz projector. Director, Charles G. Wilder.

LOS ANGELES: *Griffith Observatory and Planetarium.* Griffith Park, P.O. Box 9787, Los Feliz Station, Los Angeles 27, Calif., Olympia 1191.

SCHEDULE: Wednesday and Thursday at 8:30 p.m. Friday, Saturday, and Sunday at 3 and 8:30 p.m.; extra show on Sunday at 4:15 p.m. Zeiss projector. Director, Dinsmore Alter.

NEW YORK CITY: *Hayden Planetarium.* 81st St. and Central Park West, New York 24, N. Y., Endicott 2-8500.

SCHEDULE: Mondays through Fridays, 2, 3:30, and 8:30 p.m.; Saturdays, 11 a.m., 2, 3, 4, 5, and 8:30 p.m.; Sundays and holidays, 2, 3, 4, 5, and 8:30 p.m.; Wednesdays and Fridays, 11 a.m., for school groups. Zeiss projector. Curator, Gordon A. Atwater.

PHILADELPHIA: *Fels Planetarium.* Franklin Institute, 20th St. at Benjamin Franklin Parkway, Philadelphia 3, Pa., Locust 4-3600.

SCHEDULE: Tuesdays through Sundays, 3 p.m.; Saturdays, 11 a.m.; Saturdays, Sundays, and holidays, 2 p.m.; Wednesdays, Fridays, and Saturdays, 8:30 p.m. Zeiss projector. Director, I. M. Levitt.

PITTSBURGH: *Buhl Planetarium and Institute of Popular Science.* Federal and West Ohio Sts., Pittsburgh 12, Pa., Fairfax 4300.

SCHEDULE: Mondays through Saturdays, 2:15 and 8:30 p.m.; Sundays and holidays, 2:15, 3:15 and 8:30 p.m. Zeiss projector. Director, Arthur L. Draper.

SPRINGFIELD, MASS.: *Seymour Planetarium.* Museum of Natural History, Springfield 5, Mass.

SCHEDULE: Tuesdays, Thursdays, and Saturdays at 3 p.m.; Tuesday evenings at 8 p.m.; special star stories for children on Saturdays at 2 p.m. Admission free. Korkosz projector. Director, Frank D. Korkosz.

STAMFORD: *Stamford Museum Planetarium.* Courtland Park, Stamford, Conn.

SCHEDULE: Sunday, 4:15 p.m. Special showings on request. Admission free. Spitz projector. Director, Robert E. Cox.

★ ★ ★

Through the Universe Via HARVARD BOOKS ON ASTRONOMY

This series of 8 books, edited by Harlow Shapley and Bart J. Bok, is based upon original investigation by world-known authorities. Written in a manner that will delight and entertain the reader as well as impart facts, each volume describes exhaustively the problems of a particular field. Abundantly illustrated throughout, the books contain many new and original photographs of interest to both professional and amateur astronomers.

OUR SUN — new printing — by *Donald Menzel*, the latest of the series, is a dramatic and entertaining story of the sun and its effects upon the earth and human beings. 178 Illus., 326 Pages — $4.50

TELESCOPES AND ACCESSORIES by *George Dimitroff* and *James Baker* describes man's use of procedures and instruments of great power in analyzing the universe. 182 Illus., 309 Pages — $3.00

BETWEEN THE PLANETS by *Fletcher Watson* presents an exciting account of comets, meteors, asteroids and meteorites, and their similarities and differences in structure, size and motion. 106 Illus., 222 Pages — $3.00

EARTH, MOON AND PLANETS by *Fred Whipple* describes planets and their atmospheres and discusses the possibilities of life outside the earth. 140 Illus., 293 Pages — $3.00

THE STORY OF VARIABLE STARS by *Leon Campbell* and *Luigi Jacchia* presents the technic of observation and analyzes what we know about variable stars. 82 Illus., 226 Pages — $3.00

ATOMS, STARS AND NEBULAE by *Leo Goldberg* and *Lawrence Aller* discusses single, double, multiple, dwarf and giant, cool and hot and pulsating stars and some whose surface layers are suddenly wrenched away in cataclysmic stellar explosions. 150 Illus., 323 Pages — $3.00

THE MILKY WAY by *Bart Bok* and *Priscilla Bok* summarizes our knowledge of the Milky Way and its unsolved problems. 100 Illus., 224 Pages — $3.00

GALAXIES by *Harlow Shapley* discusses stars, star clusters, and those distant external systems that resemble our own Milky Way. 126 Illus., 229 Pages — $3.00

SEND FOR YOUR COPIES TODAY!

The Blakiston Company
1012 Walnut St. Philadelphia 5, Pa.

Please send me the books listed below. My check is enclosed. It is understood that you will refund money in full for any book if I wish to return it within 10 days.

.....

.....

.....

Name .....

Address .....

City ..... Zone .... State .....

ST 10-50

BOOKS AND THE SKY

CLIMATE THROUGH THE AGES

C. E. P. Brooks. McGraw-Hill Book Company, New York, 2nd edition, 1949. 395 pages. $4.50.

ALTHOUGH primarily for those interested in meteorology, **Climate Through the Ages** contains much that concerns astronomers. Books on astronomy look on the earth as an astronomical body, and usually treat the relation of the sun to our climate in a schematic and cursory manner. A volume that places the stress on the complexities of climate, and discusses many other factors besides the distance of the sun and the direction of the solar rays, puts the subject in better perspective.

The range of the book is very large. The first section treats of the factors that govern the climate, and the way in which their variation can affect climatic conditions. Here the sun plays a leading role, and a chapter is devoted to the direct effects of solar radiation, the possible changes in the sun's brightness, and their predictable influences on climate. It must be admitted that some of the suggestions mentioned as possible factors in climatic change, such as "variations in the distance of the nearest fixed stars," are so untenable as hardly to be worth mention, even though the author dismisses them. And the chapter contains no reference to the ionosphere, through which solar radiation certainly exerts an effect on climate.

Influences of changes in the earth's orbit are discussed in a chapter on astronomical factors of climate. That precession and variations in the obliquity of the ecliptic and the eccentricity of the earth's orbit can produce sensible climatic changes will come as a surprise to many students of astronomy.

The two later sections are devoted to geological climates and their causes and to "The Climates of the Historical Past." Both contain much material that is wholly new to most astronomers, and the latter makes especially fascinating reading.

A very clear piece of exposition, this book captures the reader's attention throughout. Discussions of various interpretations are, however, so impartial that an unsophisticated student may have difficulty separating the sheep from the goats. Those who (like the reviewer) visualize a relation most easily in graphical form will see with delight the large number of diagrams, albeit there are flaws in a few of them.

CECILIA PAYNE-GAPOSCHKIN
Harvard College Observatory

NEW BOOKS RECEIVED

WORLDS IN THE SKY, *Carroll Lane Fenton* and *Mildred Adams Fenton*, 1950, *John Day*. 96 pages. $2.50.

This is "the story of the stars, planets, and other heavenly bodies, including the one we live on," written for children about nine to 13 years old — and their parents.

★ ★

Making Your Own Telescope **The Nature of Cosmic Rays**
Atlas of the Heavens **Sky and Telescope**

Sky Publications

Mappa Coelestis Nova **Splendors of the Sky**
Relativity and Its Astronomical Implications **Moon Sets**

MAKING YOUR OWN TELESCOPE, by Allyn J. Thompson, tells the complete story of how to make and mount a 6-inch reflecting telescope, at very low total cost. Excellent for use by telescope making groups. 211 pages, 104 illustrations. **$3.50**; foreign postage 40 cents

THE NATURE OF COSMIC RAYS, by W. F. G. Swann, gives a review of the fundamental physical and atomic principles involved in the study of this most powerful of all cosmic energies. 32 pages. **50 cents**

ATLAS OF THE HEAVENS, by Antonin Becvar and associates at the Skalnate Pleso Observatory. Sixteen charts cover the entire sky to magnitude 7.75, including doubles, multiples, variables, novae; galactic star clusters, globulars, and planetaries; 1950 co-ordinates. Each chart area is 15½ by 23½ inches. **$5.00**

SKY AND TELESCOPE may be sent as a gift; if requested, a donor's card is sent to the recipient of each gift subscription.

MAPPA COELESTIS NOVA, by Josef Klepesta, is a large wall chart, colorful as well as informative. The northern sky to —45° is shown on a polar projection, and each star is colored according to its spectral class. The chart makes a fine transparency, 28 inches square. **$3.50**

SPLENDORS OF THE SKY is a bargain in astronomical photographs, with explanatory captions, now in its third printing for a total of 36,000 copies in eight years. 36 pages, each 8½ x 11½ inches. **35 cents**, plus 5 cents postage

RELATIVITY AND ITS ASTRONOMICAL IMPLICATIONS, by Philipp Frank, is an outstanding explanation of the general theory of relativity, in language suitable for the layman. 24 pages. **50 cents**

MOON SETS are 18 full-sized plates, nine for the first-quarter moon and nine for the last quarter, from Lick Observatory negatives. Each plate is on a sheet of heavy stock 12 by 18 inches, and there are key charts for named lunar features. **$2.00**

All prices are postpaid except as otherwise noted. Order from your favorite bookstore, from the Adler, Buhl, Fels, Hayden, or Morehead Planetarium (see Planetarium Notes for addresses), or write us directly. Payment should accompany all mail orders.

SKY PUBLISHING CORPORATION
HARVARD COLLEGE OBSERVATORY, CAMBRIDGE 38, MASS.

THE FOUNDATIONS OF ARITHMETIC

Gottlob Frege (translated by J. L. Austin). Philosophical Library, New York, 1950. 238 pages. $4.75.

THE QUESTION of the nature of numbers, whether they are subjective or objective, sense data or the results of a priori intuitions, first became of major concern to mathematicians in the second half of the 19th century. At that time began the great study of the logical foundations of mathematics which has led to a complete re-examination of our laws of thought and to a continuing battle between two schools of mathematicians.

One school bases its effort chiefly on the works of Dedekind, Contor, and Frege. They call two sets of objects "similar" if their members can be paired off in a one-to-one correspondence, and define "the number of objects in a set" as the "set of all sets similar to the given set." To this view there have been many objections. Bertrand Russell pointed out that "the set of all sets which are not members of themselves" is a self-contradictory notion, and therefore objected to the use of "the set of all sets" as an idea in the definition of numbers. Many such paradoxes have been brought forward and many unsatisfactory solutions proposed, but most mathematicians still adhere firmly to this approach and expect it eventually to be completely clarified and accepted.

The other view, chiefly the work of L. Brouwer, holds that the flaws in the foundation of mathematics arise from the use of Aristotelian logic when discussing infinite sets, for example, in the use of the law of the excluded middle which states that a proposition is necessarily either true or false. Thus they would say that two infinite sets may simultaneously have neither the same number of elements nor a differing number of elements. The implications of this view are that large sections of commonly accepted mathematics must be discarded as false. Between the two schools the battle still rages.

In this book, first published in 1884 under the title, **Die Grundlagen der Arithmetik,** Frege considers the earlier views of the nature of numbers and arithmetic, those of Kant, Leibnitz, Mill, and others, and criticizes each in a delightfully rambunctious fashion. He then proposes and analyzes his own definitions, based on "the set of all sets" concept, and shows how they avoid the objections which could be raised against the other theories.

The book itself is well printed, with the original German text and the English translation on facing pages. Mr. Austin's translation is excellent. He has taken great care to be consistent in his rendering of words which have slightly differing significances, and to point out in footnotes the original German words for concepts which are ambiguous in translation. The only criticism to be made is that the book needs an introduction to make clear to the reader the more recent objections to Frege's reasoning, and the defenses and extensions of it.

ARTHUR KOHLENBERG
Harvard College Observatory

LUMINESCENT STAR CHARTS

Francis Wilmot. Wilmot Luminescent Art Company, 4859 College View Ave., Los Angeles, 1950. Six charts. $7.45.

AMATEURS who have attempted to teach the constellations to the astronomically illiterate with ordinary star charts will welcome this set of six large, self-luminous maps, each one covering most of the visible sky (mid-northern latitudes) for a specific time.

Although intended for beginners, the charts are of interest to the more experienced observer in brushing up on the celestial arrangement. Many variable star observers who rely entirely on setting circles, for instance, find their knowledge of actual constellation outlines is rather rusty. But as a teaching device the set is valuable to the professional and amateur alike.

The charts are reasonably accurate and complete, but necessarily somewhat simplified for greater legibility. All stars to the 4th magnitude and some of the 5th are shown with various symbols. Especially inspiring is the glow of the Milky Way reproduced across the charts. After excitation by a good light, the fluorescent paint glows quite brightly, and after an hour of use all of the groupings and most of the printing are still recognizable. Previous study of the constellation arrangements indoors is of value during outdoor observing with the charts.

As there are six of these sky maps, they represent four-hour or two-month intervals throughout the night and year, overlapping sufficiently so that only one chart needs to be used for any particular sky. Each one is conveniently marked with the dates and time of its use. The stiff black poster board is able to withstand considerable dampness without drooping seriously. The 21" x 26" size makes each chart small enough to manipulate easily, yet large enough to read outdoors. This and the luminescence provide, in my opinion, a significant advance in practical star charts.

OWEN GINGERICH
Goshen, Ind.

SOME FIRSTS IN ASTRONOMICAL PHOTOGRAPHY

BY DORRIT HOFFLEIT

The story of the development of astronomical photography from its earliest efforts to the close of the 19th century. A chronological table summarizes events from 1839 to 1897.

39 pages, 22 illustrations. Paper bound. 60 cents postpaid.

(This is a companion booklet to Harvard College Observatory — The First Century, *published in 1946, 94 pages, 72 illustrations, 75 cents postpaid.)*

HARVARD COLLEGE OBSERVATORY
Cambridge 38 Massachusetts

FOUR NEW THEORIES

GREENHOUSE WORLD, illus. 59 pp. $1.00
A Jupiter-like cloud cover explains world-wide mild climate of geology.

LIFE ON MARS, illus. 50 pp. $1.00
Martian "canals" connect vegetation basins, identical to lunar explosion craters.

SATURN HAS RINGS, illus. 50 pp. $1.00
Saturn provides the "key" to unlock the mystery of planet development.

LAST ICE AGE, illus. 56 pp. $1.00
Processes now operating on Saturn and Jupiter can explain glacial epochs.

Send postcard for illustrated circular T-2

DONALD LEE CYR
1412 Palm Terrace, Pasadena 6, California

The Shrunken Moon
Volume IV of
Geology Applied to Selenology
By J. E. SPURR
207 pages 36 text figures
Price $4.00
•
Business Press
Lancaster, Pennsylvania

STARSCOPE

An optical star finder of new and novel design. Developed at the University of Chicago as a teaching aid and now available to the amateur astronomer.

Carefully plotted star charts are made to appear as though projected on the actual night sky. Principal stars are located and named.

STARSCOPE may be purchased at most planetariums or ordered direct with satisfaction guaranteed . . postpaid $3.00

STARSCOPE
55 Howard St. Linden, Missouri

ASTRONOMICAL SERVICES FOR YOU

You will want the new set of Astronomy Charts covering eclipses beyond the year 2000, and many other subjects.

For professional and amateur astronomers, for educators, lecturers, museums, libraries.

Two sets of Astronomical Charts (25 charts in each set), 8½ x 11, punched for loose-leaf notebook ..... $3.00 either set
Large Wall Charts, 27" x 35" (50 available), ... each $3.00
24 35-mm. SLIDES in sturdy glass mounts, chart slides and Mt. Wilson pictures, $8.50

Save by a combined order:
Both chart sets (8½ x 11) ..... $ 5.75
Either chart set and slide set $11.00
Two chart sets and slide set $13.75

We pay postage.

May we send you our new circular?

ASTRONOMY CHARTED
4 Mason Street, Worcester 2, Mass., U.S.A.

WAR SURPLUS BARGAIN

PTICS

ACHROMATIC TELESCOPE OBJECTIVES — Perfect Magnesium Fluoride Coated and cemented Gov't. Surplus lenses made of finest Crown and Flint optical glass. They are fully corrected and have tremendous resolving power and can be readily used with ¼" F.L. eyepieces. Guaranteed well suited for Astronomical Telescopes, Spotting Scopes, etc. Gov't. cost approximately $100.00.

Diameter	Focal Length	Each
54 mm (2⅛")	600 mm (23½")...	$12.50
78 mm (3 1/16")	381 mm (15").....	21.00
78 mm* (3 1/16")	451 mm (17¾")...	21.00
81 mm (3 3/16")	622 mm (24½")...	22.50
83 mm (3¼")	876 mm (34½")...	28.00
83 mm (3¼")	1016 mm (40").....	30.00

*Not coated

● We can supply ALUMINUM TUBING for the above lenses. ●

SYMMETRICAL EYEPIECE LENS SET — These sets consist of two Magnesium Fluoride coated and cemented achromats, exact Gov't. spacing. Diagram. Gives wide flat field.
½" E.F.L. (20X) Lens Set—13 mm Dia. $4.50
¾" E.F.L. (13X) Lens Set—18 mm Dia. 3.50

LENS CLEANING TISSUE—Here is a wonderful Gov't. Surplus buy of Lens Paper which was made to the highest Gov't. standards and specifications. 500 sheets size 7½" x 11". $1.00

40 POWER TELESCOPE

Coated Lenses

FOUR TELESCOPES in One because of Adjustable Power Eyepiece 10X, 20X, 30X and 40X. Magnesium fluoride hard coated precision American-made lenses. Achromatic objective lens 2⅛" (53 mm) dia. Length closed 9½", open 27½". Genuine leather covering. Weight 28 oz. $35.00

Smaller Model 40-power telescope 1 7/16" (36 mm) objective, length open 26¼" ..... Only $29.75

Rectangular Magnifying Lens — Seconds, sells for $6.50. Size 2" x 4" $1.00
Optical Peep Sight — Use as camera view-finder, etc. Dia. 1½", weight 1½ oz. 1.50
Hobbyist Set — Fun for Young and Old. 10 assorted lenses and booklet. 1.00
First Surface Mirror 12"x15" ¼" thick ...$8.75
First Surface Mirror 8"x10" ¼" thick ... 4.25
First Surface Mirror 4"x 4" ⅛" thick ... 1.50
First Surface Mirror 1¼"x1½" 1/16" thick .25

Mounted eyepiece has 2 perfect achromatic lenses 29 mm in dia. Designed in order to give good eye relief. Cell fits 1¼" tube.
1¼" E.F.L. (8X). $4.50
1⅞" E.F.L. (5½X) $4.00

3x ELBOW TELESCOPE — Makes a nice low-priced finder. 1" Achromatic Objective. Amici Prism Erecting System, 1⅜" Achromatic Eye and Field Lens. Small, compact, light weight, 2 lbs. Gov't. Cost $200.

Plain Optics $6.50 Coated Optics $10.50

"MILLIONS" of Lenses, etc. Free Catalogue

We pay the POSTAGE — C.O.D.'s you pay postage. Satisfaction guaranteed or money refunded if merchandise returned within 10 days.

A. JAEGERS 93-08S 95 AVE. OZONE PARK 16, N. Y.

GLEANINGS FOR ATM's

EDITED BY EARLE B. BROWN

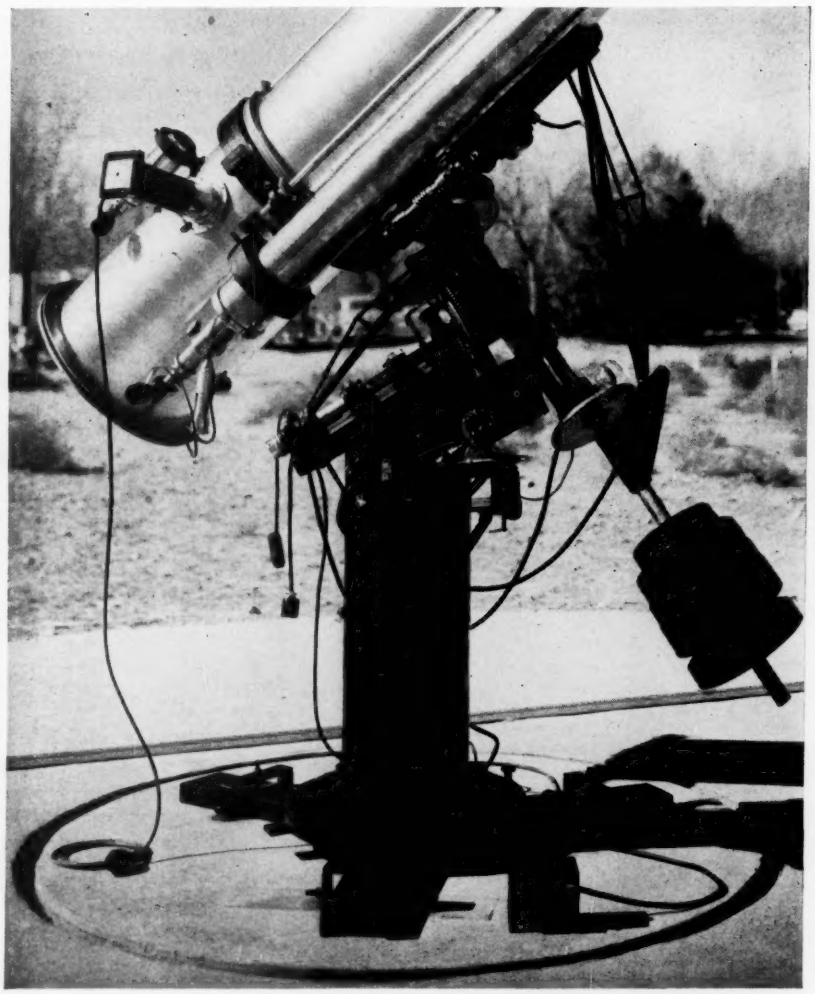
A Versatile and Well-equipped Reflector

HERE at New Mexico College of Agriculture and Mechanic Arts, I use in the astronomy courses a 17-inch reflector (pictured on the front cover, this issue) which I have designed and built. It has taken over six years to build this instrument to its present form, but it has certainly been well worth it in the convenience, versatility, and usefulness in research and teaching.

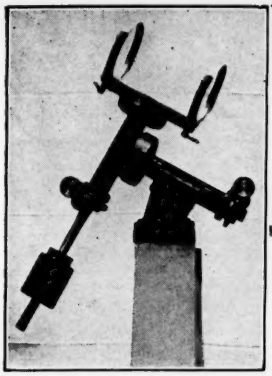
It is a modified Cassegrainian-Newtonian combination on a modified German equatorial mounting with synchronous electric driving clock, plus electric remote control slow motions for positioning and electric remote control slow-slow motion on the declination axis; it has electronic frequency rate control for the Telechron drive on the polar axis for photographic guiding.

Considerable latitude for different types of work is possible as the Newtonian optical system is f/7.8 and the Cassegrainian is f/22.8. The primary mirror was ground and polished in my own laboratory on an automatic grinding machine, and figured by J. W. Fecker at the focus with a master optical flat to an accuracy of between 1/10 and 1/20 wave length of sodium light. The secondary mirror was manufactured by the Perkin-Elmer Corporation; the Cassegrainian flat, by Leroy M. E. Clausing; and the Newtonian prism, by Bausch and Lomb. All of these optical elements with the exception of the prism are of pyrex glass.

The instrument has many features which lend to its excellent performance. The tube is riveted 24ST aluminum alclad, cork insulated, worm-gear driven to rotate in a rigid, aluminum cradle. The primary mirror is on an 18-point flotation system with special floating ball-point edge support. Other features include low-diffraction, single-strut, swing-over spiders for the secondary support; lighted setting circles with slip-ring circles on the polar axis; a removable Newtonian nose



A closeup of the mounting of Dr. Engle's 17-inch reflector, showing the two drives on the pier and the arrangement for Cassegrainian photography. Photograph by Gilbert Moore. The front cover shows the other side of the pedestal.



Amateur Telescope Makers Supplies

Ramsden Eyepieces
Combination Eyepiece and Prism Holders
Mirror Cells
Finders
Equatorial Mountings
Prisms

Send for a price list

C. C. Young 25 Richard Road East Hartford 8, Conn.

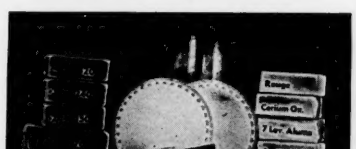
ALUMINIZING

HARD BER-AL COATING

Our exclusive high-reflectivity BER-AL coatings are free from chromium and they are not overcoated with fluorides or quartz. They can be removed easily, when desired, without harm to the glass surface below. Prices for BER-AL coatings, f.o.b. Chicago, are: $2.50 for 6" diameter mirrors, $3.50 for 8", $5.00 for 10", and $8.00 for 12½". Larger sizes up to 24" diameter on request.

LEROY M. E. CLAUSING
4544 N. Western Ave. Chicago 25, Ill.

New Low Prices on PYREX Reflecting Telescope Kits



Two circle dials with every Pyrex Kit.

The most complete kits on the market. In addition to the usual supply of abrasives, rouge, etc., you get the new, fast-polishing cerium oxide to save hours of work. You can get a brass diagonal holder (spider) for only $1.00 additional if ordered with a telescope kit. Prices quoted below are for a Genuine Pyrex telescope blank and a plate glass tool.

PYREX MIRROR KITS

4"	$ 5.25	6"	$ 6.75
8"	9.75	10"	16.75
12½"	31.75	16"	65.00

4" to 16" PYREX CARRIED IN STOCK

PLATE GLASS KITS

6" x ¾"	$4.75	6" x 1"	$ 5.25
8" x 1"	7.25	9¾" x 1½"	12.50

Postage Paid to 1st and 2nd postal zones from N. Y. Add 5% 3rd and 4th zones, 10% 5th and 6th zones. Add 15% 7th and 8th zones.

Parabolic pyrex mirrors made to order.

Send for free catalog of optical supplies.

DAVID WILLIAM WOLF
334 Montgomery St. Brooklyn 25, N. Y.

section at the upper end of the tube, where the prime-focus assembly projects for ease in loading photographic plates.

Note the truss support that gives a triangular structure to each axis to increase the rigidity of the mounting but permit observation to all parts of the sky. The mounting is entirely of steel, on a concrete pier separate from the outside concrete ramp. The roll-off building, not shown in the pictures, runs on the steel tracks seen at the base of the pier.

The mounting picture shows the two drives on the pier. The latest driving clock is a Telechron C5M 12-watt system with frequency control. The older, auxiliary drive is a 1/20 horsepower Bodine synchronous system with a friction rate control micrometer unit. At the eyepiece of the 6-inch refractor is shown one of the crosshair lighting units for guiding. The remote control slow-motion box is resting on the concrete pier in both pictures. Electric automatic switches shut the instrument off if it travels too far in right ascension. The closed tube is ideal in this dusty country, but an opening at the mirror flange is used to let air flow in the tube when needed.

At the modified Cassegrainian focus, there is a camera back to take 4-x-5-inch Graphic plateholders, but for photography of the planets there is an extension tube and camera back unit taking Eastman 6.5-x-9-cm. metal plateholders. For the planets, equivalent focal lengths up to 150 feet may be obtained, using either a Bausch and Lomb 48-mm. microtessar lens or a Bausch and Lomb achromatic 4-power microscope objective; filter holders take either Eastman series 6 Wratten filters or 1-inch unmounted B glass Wratten filters covering the range from 3,000 to 9,000 angstroms. The planetary extension tube and camera back unit are shown in the picture, including the air-operated shutter tube and bulb (resting on the pier base). At the prime focus the camera back unit also takes 6.5-x-9-cm. metal plateholders. All the photographic units are equipped with the air-operated shutters, which can be used without touching the telescope. The prime-focus unit is best suited for long exposures, and an off-axis prism is used at the Newtonian position for guiding.

The instrument has eight eyepieces, several of which are achromatic and coated, giving powers upward from 51 at the Cassegrainian and from 53 at the Newtonian focus. My favorite planetary setup is a Kellner 35-mm. effective focal length coated ocular at the Cassegrainian focus, giving a magnification of 281x. There is a Mogey solar wedge with filters, and a 3-inch achromatic finder, in addition to the 6-inch guiding telescope already mentioned.

There is a photoelectric photometer optical column with a 45-degree swing-out prism unit for guiding at the Cassegrainian focus, with a new 1P21 Kron-type direct-current amplifier (being built).

I shall be glad to show this telescope to any amateur or professional astronomers traveling through Las Cruces, where New Mexico A. and M. is located.

PAUL R. ENGLE
Dept. of Mathematics and Astronomy
Box 144, State College, N. M.

WAR SURPLUS BARGAINS

Government's 7 X 50 Binoculars

Assemble Them Yourself! Complete Optics! Complete Metal Parts! Save More Than ½ Regular Cost!

METAL PARTS—Set includes all metal parts—completely finished — for assembly of 7 X 50 Binoculars. No machining required. Sturdy Binocular Carrying Case is optional with each set of Metal Parts.

Stock #842-Y. $39.40 Postpaid, plus $4.80 for Case. Total $44.20

OPTICS–Set includes all Lenses and Prisms needed for assembling 7 X 50 Binoculars. These are in excellent condition — perfect or near-perfect — and have new low reflection coating.
Stock #5102-Y ..... $25.00 Postpaid

Note: These are fine quality standard American-made parts, not Japanese.

NOTICE! If you buy both Binocular Optics and Binocular Metal Parts, add 20% Federal Tax.

A WONDERFUL BUY

AMAZING POCKET-SIZE 10-POWER SPOTTING SCOPE—Complete With Tripod and Swivel Head— Only 5½" long—8½" high on tripod. Adapted from Army telescope and worth many times our price. Excellent for clarity and sharpness. Has prism erecting system, achromatic objective, Ramsden eyepiece. Lenses low-reflection coated. Ideal scope for sportsmen and hunters.
Stock #955-Y ..... $14.95 Postpaid

POLAROID VARIABLE DENSITY ATTACHMENT — Consists of two mounted Polaroid filters. Control knob rotates one about the other giving variable density. Used in photography, experiments in polarized light, controlling light transmission, etc.
Stock #693-Y ..... $3.00 Postpaid

NON-ABSORBING BEAM-SPLITTING MIRROR —Latest development! Optically flat to ¼ wave length. Size: 1-15/16" x 2-15/16"—⅜" thick. Reflects approximately 50% and transmits approximately 50%. No light is absorbed. Has a three-layered film which accomplishes non-absorption.
Stock #567-Y ..... $5.00 Postpaid

MOUNTED TELESCOPE EYEPIECE — Kellner type. Excellent astronomical and other telescopes. War Surplus. Government cost about $18.00. Focal length 24 mm. Lens diameter 23 mm. Unusually wide field.
Stock #5189-Y ..... $3.25 Postpaid

CROSSLINE RETICLE — Dia. 29 mm.
Stock #2036-Y ..... 50c Postpaid

SPECIAL! SPECIAL!

RONCHI RULINGS

Black Line Grating

Plate glass with etched parallel black lines — space between the lines is same as thickness of the ruled line itself. Made by photographic process. Number of lines per inch ranges from 65 to 133 as shown below. Normally cost $4.00 to $5.00 per sq. inch. Used for testing astronomical mirrors, testing microscope objectives and magnifiers; used in pairs to see diffraction pattern. (Some seconds, with slight scratches)

1 in. x 1 in. Stock No.	Lines Per In.	Price	2 in. x 2 in. Stock No.	Lines Per In.	Price
2122-Y	65	$ .75	2133-Y	65	$1.50
2126-Y	85	.75	2134-Y	85	1.50
2127-Y	110	1.00	2136-Y	110	2.00
2128-Y	120	1.00	2137-Y	120	2.00
2129-Y	133	1.00	2138-Y	133	2.00

All above sent Postpaid.

FIRST-SURFACE MIRRORS

Stock #539-Y—60 mm. x 80 mm. .. 75c Postpaid
Stock #558-Y—45 mm. x 74 mm. .. 50c Postpaid
Stock #547-Y—43 mm. x 140 mm. .. 50c Postpaid
Stock #534-Y—25 mm. x 29 mm. .. 25c Postpaid

SIMPLE LENS KITS!—THE LENS CRAFTERS DELIGHT! Fun for adults! Fun for children! Kits include plainly written illustrated booklet showing how you can build lots of optical items. Use these lenses in photography for copying, ULTRA CLOSE-UP SHOTS, Microphotography, for "Dummy Camera," Kodachrome Viewer, Detachable Reflex View Finder for 35-mm. cameras, Stereoscopic Viewer, ground glass and enlarging focusing aids. And for dozens of other uses in experimental optics, building TELESCOPES, low power Microscopes, etc.
Stock #2-Y—10 lenses ..... $1.00 Postpaid
Stock #5-Y—45 lenses ..... $5.00 Postpaid
Stock #10-Y—80 lenses ..... $10.00 Postpaid

We Have Literally Millions of WAR SURPLUS LENSES AND PRISMS FOR SALE AT BARGAIN PRICES. Write for Catalog "Y"—FREE!

Order by Stock No. *Satisfaction Guaranteed*

EDMUND SALVAGE CO.
BARRINGTON, NEW JERSEY

SKY-SCOPE

The new and improved 3½-inch Astronomical Telescope that amateurs everywhere are talking about.

Completely Assembled—**$25.00**

Equatorially Mounted, 60 Power
¼-wave Aluminized Mirror
Ramsden Type Ocular
100x & 35x Supp. Eyepieces, ea. $5.00

We invite your attention to our free brochure describing in a straightforward manner the instrument's amazing performance.

THE SKYSCOPE CO., INC.
475-s Fifth Avenue, New York 17, N. Y.

Coated Astronomical Objective
3⅛ inch by 50-inch focal length, air spaced, in black anodized duraluminum barrel.
•Individually hand corrected and figured•
Price $62.00
Dioptric Engineering Laboratories
47 West 56th St., New York 19, N. Y.

Attention!

OBSERVATORIES

ASTRONOMERS

COLLEGES

The startling performance of the Goodwin ultra-modern Barlow Lens, in sharpening resolutions of giant down to 3-inch apertures, justifies sending it out on approval. Simply request on your Observatory, University, or College letterhead, enclose 21c postage, test for two weeks, and remit $17.50 only if positively astonished. Otherwise return lens prepaid. Private individuals send $17.50. Money refunded after two weeks trial for lens returned undamaged.

Barlow comes in chrome 4-inch adapter tube fitting 1¼-inch eyepiece holders. A 13-page Symposium on the Goodwin Barlow sent on receipt of self-addressed long envelope bearing three 3c stamps return postage.

F. L. GOODWIN

345 Belden Ave. West. Chicago 14. Ill.

LETTERS

Sir:

I am compiling a list of miniature constellations, hoping to add a pamphlet, eventually, to the beginning stargazer's library. RFT enthusiasts, in the absence of the old reliable moon, are often strapped for telescopic entertainment for friends and children they are trying to interest.

For example, there is a fine fanlike asterism in Canis Major, at Delta; a miniature Hydra at Anilam in Orion; a perfect snail near Aquila—all suitable and pleasing objects for RFT's or field glasses at about 10x.

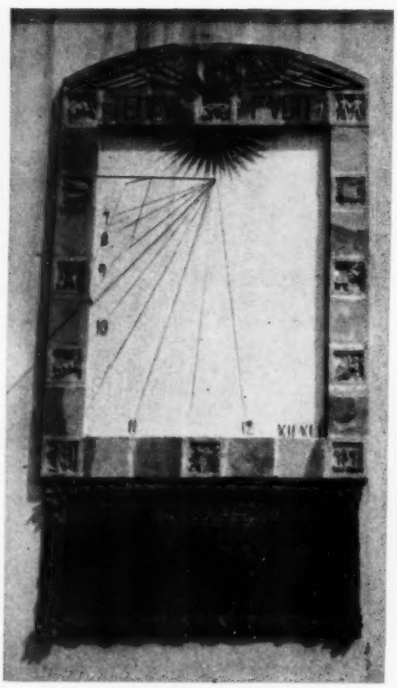
Would readers of **Sky and Telescope** like to contribute suggestions for such a collection? H. R. PARADISE
10216½ 47 S.W., Seattle 66, Wash.

Sir:

There are amateurs who are interested in what is called the poetry of astronomy and who are always on the lookout for new examples of it. Anyone who has not yet noticed Virginia Woolf's essay, "The Sun and the Fish," in her latest posthumous volume, **The Captain's Death-Bed,** might find in it a thrilling, short, **different** description of a solar eclipse — which makes it inspirationally evident that even a completely cloud-obscured totality should never be written off as an observational failure. P. V. RIZZO
1881-61st St., Brooklyn 4, N. Y.

Sir:

Enclosed are views of a sundial located on the outer wall of the Fabrica Nacional de Liquores in San Jose, Costa Rica. Note the signs of the zodiac and the table of data below the sundial. This table includes "correcciones para este reloj de sol," and "datos sobre la ciudad de San Jose." ARTHUR A. ALBRIGHT
Box 175, Gatun, Canal Zone



A wall sundial in Costa Rica.

EVERYTHING FOR THE AMATEUR

TELESCOPE MAKER

KITS 6" ... $5.50 up; Pyrex, 6" ... $7.50 up. Other sizes in proportion.

ALUMINIZING
Superior Reflecting Surface, Fine Finish. Will not Peel or Blister. Low Prices.

Mirrors Tested Free | **Prisms Eyepieces Accessories** | **Send for Free Catalog**

MONEY BACK GUARANTEE

Precision Optical Supply Co.
1001 E. 163rd St., New York 59, N. Y.

AN ALBUM OF CELESTIAL PHOTOGRAPHS
By A. L. Bedell

A selection of astronomical pictures by the world's large telescopes.

65 pictures with separate captions, bound in a heavy paper cover, originally priced at $1.50, now closing out at $1.25 postpaid.

SKY PUBLISHING CORPORATION
Cambridge 38, Massachusetts

SKY-GAZERS EXCHANGE

Classified advertising costs 10 cents a word, including address; minimum charge $2.50 per ad. *Remittance must accompany order.* Insertion is guaranteed only on copy received by the first of the month preceding month of issue; otherwise, insertion will be made in next available issue. We cannot acknowledge classified ad orders. Write Ad Dept., Sky and Telescope, Harvard Observatory, Cambridge 38, Mass.

FOR SALE: 10" aluminized pyrex mirror, f/4.0, corrected to within 97 per cent of a parabolic figure. Write L. W. Freckman, 1385 Oakwood, Des Plaines, Ill.

OBSERVATIONAL NOTE August 23, 1950. Observing Jupiter with 4" refractor, f/18, working power 144. Red Spot hollow large white oval surrounded by darkish border: difficulty holding detail until Metzger processed Glare Reduction and Filter Screen placed over O.G. when details immediately steadied enough for drawing. Read our ad Sky-Gazers Exchange September **Sky and Telescope** for more information. The MGRS designed for refractor or reflector. We must know outside diameter of your cell block or mirror tube. Price $3.00. Order today. Hal Metzger, Alfred Station, N. Y.

INSTRUMENTS: Star camera f/2.5, 7" f.l.; rich-field binoculars 3", 12x; wide-field camera obscura for home or trailer. Write for details. H. E. Paul, Norwich, N. Y.

ELECTRIC DRIVES to fit your telescope mount. Standard model $65.00. Special model (with setting circle) $125.00 F.O.B. Inquiries invited. Fellows Engineering Works, Middle Haddam, Conn.

FOR SALE: Limited number new 5" f/5 achromatic objectives. Excellent color correction. Corrected for astronomical use. Ideal for rich-field telescopes, collimators, binoculars, or photographic work. Price $75.00. John Day, 2852 Highview Ave., Altadena, Calif.

BARLOW LENS: Send stamped return long envelope with 9c postage for free truly astounding 13-page educational information as to how the Goodwin Barlow can greatly improve your telescope images and magnifications. F. Goodwin, 345 Belden Ave., Chicago 14, Ill.

FOR SALE: Weather observer's theodolite, 27 power, inverting field, with carrying case, tripod. $75.00. Correspondence invited. R. Soucy, 508 Monroe Pl., Falls Church, Va.

ATLAS CELESTE, International Astronomical Union's official star atlas to magnitude 6.0, whole sky, 26 maps; star catalogue to magnitude 4.5. Only $2.55 postpaid. Herbert A. Luft, 42-10 82nd St., Elmhurst, N. Y.

OBSERVER'S PAGE

Universal time is used unless otherwise noted.

Occultations of Star Clusters — The Pleiades

THE CURRENT SERIES of occultations of the Pleiades was first observable in the United States on January 28, 1950. From time to time through the year 1953, a number of occultations of this famous cluster will take place, and observers throughout the country may wish to predict the circumstances of those visible at their local stations. Of immediate interest are the events of the night of October 27-28, 1950.

For those who live near the standard stations, tabulated on the Observer's Page of **Sky and Telescope,** satisfactory predictions may be made in most cases by applying the **a** and **b** coefficients listed therein. If the star in question undergoes a nearly grazing occultation, these values are omitted. If the observer is situated more than 300 miles from the nearest standard station, application of the coefficients is unreliable. At times a star will just miss being occulted at the standard station and not be listed at all.

In cases such as these, an independent method is required, such as that devised by the writer and first used for the occultations of the Pleiades on August 7, 1950, visible from the eastern part of the country within the first two hours after moonrise. Sky conditions were very favorable in Rochester on August 7th, and I succeeded in timing the emersion of 27 Tauri at 5:22:01.6, using simple camera apparatus.

The system consists essentially of determining the apparent position of the moon at hourly intervals and plotting it on a star chart on which the stars are located with a minimum of distortion. This condition is attained if the disk of the moon can be satisfactorily plotted as a circle. In Fig. 1, **a** represents the location of a small square region within which a rectilinear plot of the right ascensions and declinations of the stars introduces a minimum of distortion. This is the way the equatorial zones are plotted in the Skalnate Pleso **Atlas of the Heavens.** For stars within a degree of the equator, or of the circle of constant right ascension through the center of the diagram, the distortion is negligible for purposes of predicting occultations.

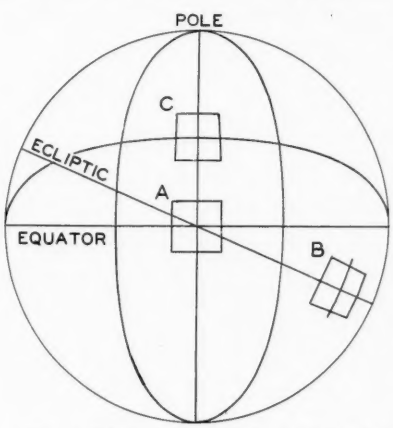


Fig. 1. Distortionless regions of the sky for graphical occultation predictions.

Since the moon's path makes small oscillations about the ecliptic, a plot of celestial longitude and latitude, represented by the relatively larger area at **b** in Fig. 1, is much more satisfactory than one of right ascension and declination when showing the stars that are occulted. In order to compute these co-ordinates, account must be taken of the inclination of the equator to the ecliptic. Stars close to the ecliptic are then plotted with the same degree of accuracy as those near the equator in the former case. This is satisfactory for occultations when the moon is near a node, especially during a total lunar eclipse.

In the general case, the moon will be more than a degree from both the equator and the ecliptic. The highest order of accuracy is then obtained by using as a reference line the arc of constant right ascension through the center of the region of stars that are to be occulted. The second reference line is a great circle of the celestial sphere perpendicular to it, as shown at **c** in Fig. 1. One might call the resulting co-ordinates occultation latitude and longitude. It is much easier to compute them than it is to determine ordinary celestial latitude and longitude. The only data needed are the right ascensions and declinations of the stars involved.

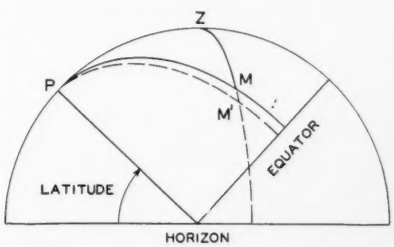


Fig. 2. Illustrating the celestial triangle.

The position of the moon is found by the conventional methods of solution of the astronomical triangle, **PZM** in Fig. 2. The celestial pole is at **P,** the observer's zenith at **Z,** and the moon at **M.** From the geographical longitude and data in the almanac, the moon's hour angle is determined. Together with the observer's latitude and the moon's declination, one can then compute the azimuth and uncorrected altitude of the moon at the local station.

The reader may imagine the earth to be replaced by a small, similarly oriented globe located at its center. From the image of the local station, situated on this globe, the moon would be seen in the sky at **M.** This is called the geocentric position. The apparent position at the true station is at **M'** in Fig. 2, and it is found by applying the correction for parallax. The arc **M'M** is the difference in local and geocentric altitudes, but the azimuths are equal to each other. The altitude difference is the angular separation of the observer's station from the

A New SPITZ PLANETARIUM

is now in operation at:

CHILDREN'S MUSEUM

Brooklyn, New York

SCIENCE ASSOCIATES

401 N. Broad St. Phila. 8, Pa.

Now! Saturn 3 Inch PORTABLE REFRACTORS

Only $199.00

For the first time an instrument capable of serious astronomical research is available for less than $200.00! The Saturn 3 Inch Portable Refractors are precision made by the West's largest makers of observatory instruments; objective lenses are highest grade precision ground, achromatic f-15 crown and flint glass, all moving parts are precision machined.

Although the Saturn 3 Inch Refractor has a 45 inch focal length, the instrument is easily portable, weighing less than thirty pounds, including tripod.

Saturn 4 Inch Portable Refractors from $345.00; larger instruments manufactured to order.

Write for literature giving full information on the Saturn Refractors.

Tinsley Laboratories

2530 Grove Street
Berkeley, California

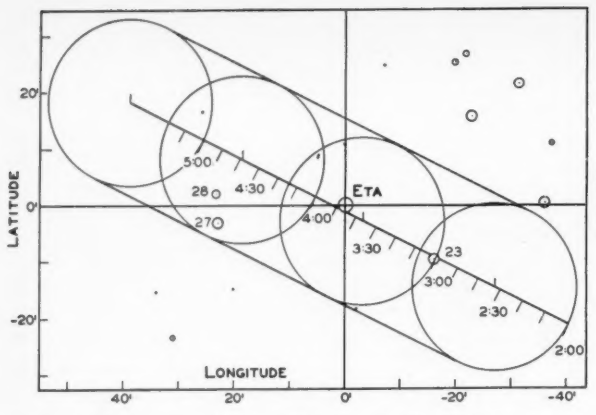


Fig. 3. The moon in the Pleiades at Rochester. Stars as circles are brighter than magnitude 6.55; dots are between 6.55 and 7.54.

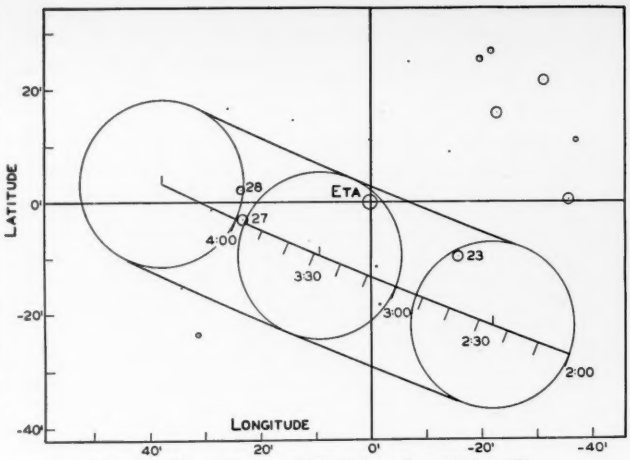


Fig. 4. The same as Fig. 3 but for station H.

center of the earth's disk as it would appear to a person on the moon.

Solution of the spherical triangle **PZM'** next gives the apparent declination and hour angle of the moon as seen at the local station. The latter is converted to right ascension, whereupon the apparent occultation latitude and longitude of the moon's center can be computed.

Fig. 3 shows the path of the moon among the Pleiades on the evening of October 27-28, as seen from Rochester, N.Y. The position of the moon is indicated at hourly intervals from 2:00 to 5:00 UT. Along the locus of the center of the disk is a scale marking the positions of the following limb at 10-minute intervals. Occultation latitude and longitude are scaled in minutes of arc, positive toward the north and east, respectively. Alcyone, Eta Tauri, the brightest star in the cluster, is chosen as the origin of these coordinates. Tangent curves outline the zone of stars that are occulted.

A graduated circular disk, scaled to the angular size of the moon's diameter, may be used for determining the times and position angles of immersion and emersion. Using the chart in this way, the author has noted the times to an accuracy of half a minute and the position angles to two degrees. More precise results may be obtained from the same data by algebraic formulas in place of the simple disk.

Notice from Fig. 4 that the same four bright stars will disappear at station **H** as at Rochester, but the times and position angles will be considerably different. In the West, the moon will appear to travel among the stars at a much greater speed because it will be at a lower altitude than in the East. As the moon gets high in the sky, the rotation of the earth carries the observer relatively faster in the direction in which the moon revolves. The result is an apparent retardation of the moon's eastward motion that is even evident from hour to hour on each diagram.

The predicted times and position angles for Rochester, N. Y., according to this method are, first for immersion and then for emersion: **23 Tauri,** 1:53.5 65°, 3:00.6 242°; **Eta Tauri,** 2:34.2 60°, 3:46.2 248°; **27 Tauri,** 3:35.3 117°, 4:19.4 189°; **28 Tauri,** 3:31.5 93°, 4:37.1 213°.

The emersion of **23 Tauri** at station **H,** not given in the **Ephemeris,** is predicted at 2:37.6 287°. Immersion of this star takes place below the horizon.

This method results in considerable saving of time and effort in predicting occultations of star clusters. Copies of a single chart, drawn from a set of simple trigonometrical computations, suffice for all occultations of a particular cluster visible at any and all stations in a given year. It is not necessary to compute the hour angles, altitudes, and azimuths of the stars. All that is required for any particular date and station is the calculation of the moon's position as described above. The method is equally effective when a single star or planet is to be occulted, the object in question being placed at the origin of co-ordinates on the chart of latitude and longitude.

An easy way to observe a number of successive occultations is to use a low-power telescope, which need not be equatorially mounted but which can be held steady. A time record may then be obtained using a small camera with flash bulbs to photograph an electric clock with a sweep-second hand. Radio time signals may be used for calibrating the clock, which need not be accurately set. The observer merely flashes the camera at the instant of each immersion and emersion witnessed. At suitable intermediate intervals he does the same in coincidence with the radio signals. The film is advanced after each exposure, and the actual times of the phenomena are later found by proper subtraction of the time records. It is hoped that the human response lag in releasing the shutter at the instants of visible and audible signals may compensate each other in part and minimize the error in timing.

PAUL W. STEVENS
2322 Westfall Rd.
Rochester 18, N. Y.

ED. NOTE: Space does not permit publication of the formulas supplied by Mr. Stevens with this article, but he will send them to readers who forward self-addressed stamped envelopes.

OCCULTATION PREDICTIONS

October 27-28 **23 Tauri** 4.2, 3:43.4 +23-47.6, 16, Im: **A** 1:54.1 −0.5 +1.8 73; **B** 1:59.0 −0.4 +1.9 68; **C** 1:46.0 −0.4 +1.8 73; **D** 1:53.9 −0.2 +1.9 63; **E** 1:47.4 +0.2 +1.9 53; **F** 1:35.0 +0.4 +1.5 61. Em: **A** 3:02.7 −0.6 +2.1 233; **B** 3:08.3 −0.7 +2.0 240; **C** 2:52.2 −0.5 +2.0 233; **D** 3:00.6 −0.6 +1.9 246; **E** 2:47.8 −0.4 +1.5 257; **F** 2:32.3 0.0 +1.4 250; **G** 2:52.4 −0.5 +1.0 306; **I** 2:46.6 . . . . . 319.

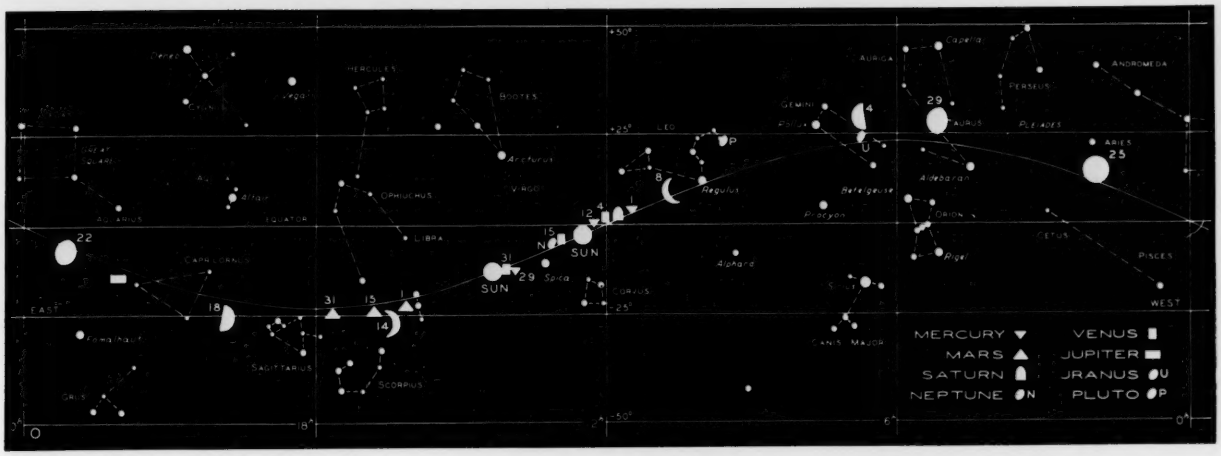
October 27-28 **Eta Tauri** 3.0, 3:44.5 +23-57.1, 16, Im: **A** 2:35.9 −0.8 +2.0 68; **B** 2:41.0 −0.6 +2.0 61; **C** 2:26.4 −0.6 +1.9 67; **D** 2:34.6 −0.3 +2.1 56; **E** 2:26.0 +0.1 +2.1 45; **F** 2:10.7 +0.3 +1.8 52; **H** 2:35.1 +1.0 +2.4 13. Em: **A** 3:50.1 −1.0 +1.9 238; **B** 3:54.7 −1.1 +1.8 246; **C** 3:38.1 −0.8 +2.0 237; **D** 3:45.1 −1.0 +1.8 251; **E** 3:28.0 −0.8 +1.4 263; **F** 3:10.4 −0.4 +1.3 256; **H** 3:06.8 −0.4 +0.3 302.

October 27-28 **27 Tauri m** 3.8, 3:46.2 +23-54.1, 16, Im: **A** 3:52.3 . . . . . 140; **B** 3:44.3 −2.5 −0.2 119; **C** 3:42.0 . . . . . 142; **D** 3:31.3 −1.9 +0.6 111; **E** 3:11.7 −1.0 +1.3 97; **F** 2:56.9 −0.9 +0.8 104; **G** 3:24.6 +0.2 +1.9 52; **H** 3:00.7 +0.4 +1.5 65; **I** 3:24.7 +0.4 +1.9 45. Em: **A** 4:10.7 . . . . . 166; **B** 4:28.8 +0.1 +4.2 189; **C** 3:55.2 . . . . . 162; **D** 4:21.8 −0.1 +3.5 197; **E** 4:09.6 −0.1 +2.7 209; **F** 3:45.3 +0.4 +2.8 201; **G** 4:24.2 −0.4 +1.7 261; **H** 3:57.9 0.0 +1.5 247; **I** 4:18.9 −0.3 +1.6 270.

October 27-28 **28 Tauri** 5.2, 3:46.2 +23-59.1, 16, Im: **A** 3:39.5 −2.2 +0.5 106; **C** 3:28.1 −2.1 +0.6 107; **E** 3:14.6 −0.8 +1.6 82; **F** 2:56.6 −0.4 +1.3 84; **H** 3:06.3 +0.5 +1.8 48. Em: **A** 4:38.3 −0.4 +3.4 200; **B** 4:46.9 −0.8 +2.8 212; **C** 4:24.2 −0.2 +3.5 198; **D** 4:37.5 −0.7 +2.7 217; **E** 4:22.3 −0.6 +2.3 223; **F** 3:57.5 −0.1 +2.2 221; **G** 4:24.8 −0.7 +1.4 280; **H** 4:01.2 −0.2 +1.2 265; **I** 4:17.4 −0.6 +1.3 291.

October 30-31 **49 Aurigae** 5.0, 6:32.1 +28-03.8, 19, Im: **A** 7:18.9 −2.1 −0.1 106; **C** 7:10.0 −2.3 −0.5 117; **E** 6:45.0 −1.5 +1.0 99; **F** 6:30.5 −1.7 −0.1 118; **H** 6:21.5 +0.1 +1.7 70. Em: **A** 8:48.6 −2.2 +0.4 260; **B** 8:46.5 −2.0 −0.1 273; **C** 8:34.6 −2.3 +1.6 246; **D** 8:34.1 −2.1 +0.6 265; **E** 8:07.2 −1.7 +1.4 255; **F** 7:37.1 −1.0 +2.7 230; **G** 7:39.6 −1.5 −0.3 316; **H** 7:25.2 −0.8 +0.9 277; **I** 7:26.7 −1.6 −0.9 328.

For standard stations in the United States and Canada, for stars of magnitude 5.0 or brighter, data from the **American Ephemeris** and the



THE SUN, MOON, AND PLANETS THIS MONTH

The sun, on the ecliptic, is shown for the beginning and end of the month. The moon's symbols give its phase roughly, with the date marked alongside. Each planet is located for the middle of the month and for other dates shown.

Mercury reaches greatest elongation, 17° 55′ west of the sun, on October 3rd. This is close to the minimum angle the planet attains at an elongation; perihelion with the sun occurs on October 2nd. The first week of October finds Mercury rising 1½ hours before the sun. Easily observable at elongation, this elusive planet is of magnitude −0.2, brightening to −0.9 on the 13th.

A close conjunction of Mercury and Saturn takes place on the morning of October 6th. Mercury will be 16′ south and over 1½ magnitudes brighter. Venus will be visible below this pair.

Venus may be observed for the last time this year in the morning sky during October. On the 1st, it will rise an hour before the sun, decreasing to 15 minutes on the 30th.

Mars continues its rapid eastward motion, crossing the constellations of Scorpius and Ophiuchus this month. No longer conspicuous, the ruddy planet now sets 2½ hours after the sun. On October 8th, Mars passes 3½° north of Antares. Comparison of the planet and its "rival" will be exceedingly interesting, for they are both at this time of apparent magnitude +1.2.

Jupiter remains the only bright planet visible in the midnight sky. It is on the meridian three hours after sunset and continues at a brilliant −2.2 magnitude. The equatorial diameter is 45″, easily discerned in a small telescope.

Saturn rises two hours before the sun in the morning sky on the 15th, rapidly leaving the vicinity of the sun. The ringed planet has moved into Virgo, and is north of Beta. Telescopists may now view the northern face of the Saturnian ring system, inclined 1°.7 to our line of sight. On October 6th, Mercury will be only 16′ south of Saturn, a fine sight.

Uranus attains western quadrature with the sun on October 3rd, therefore rising about midnight. The planet appears almost stationary all month, for retrograde or western motion begins on the 16th. Look 2° due south of Epsilon Geminorum for a 6th-magnitude "star"; that will be Uranus.

Neptune enters the morning sky on October 11th, passing conjunction with the sun at that time; hence the planet is invisible.

E. O.

British Nautical Almanac are given here, as follows: evening-morning date, star name, magnitude, right ascension in hours and minutes, declination in degrees and minutes, moon's age in days, immersion or emersion; standard station designation, **UT**, **a** and **b** quantities in minutes, position angle on the moon's limb; the same data for each standard station westward.

The **a** and **b** quantities tabulated in each case are variations of standard-station predicted times per degree of longitude and of latitude, respectively, enabling computations of fairly accurate times for one's local station (long. **Lo**, lat. **L**) within 200 or 300 miles of a standard station (long. **LoS**, lat. **LS**). Multiply **a** by the difference in longitude (**Lo** — **LoS**), and multiply **b** by the difference in latitude (**L** — **LS**), with due regard to arithmetic signs, and add both results to (or subtract from, as the case may be) the standard-station predicted time to obtain time at the local station. Then convert the Universal time to your standard time.

Longitudes and latitudes of standard stations are:

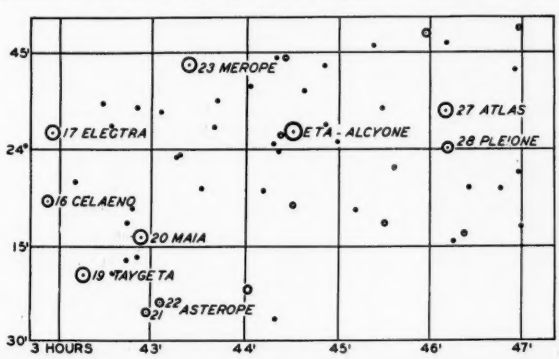
A +72°.5, +42°.5	**E** +91°.0, +40°.0
B +73°.6, +45°.6	**F** +98°.0, +31°.0
C +77°.1, +38°.9	**G** +114°.0, +50°.9
D +79°.4, +43°.7	**H** +120°.0, +36°.0
	I +123°.1, +49°.5

DEEP-SKY WONDERS

THE PLEIADES, famed in both science and mythology, are one of the choice offerings of fall and winter skies, and this month's passage of the moon through them is of special interest. Astronomically, the Pleiades are merely a galactic or open cluster so near that the naked eye can resolve the individual stars, but esthetically they have enhanced the imaginations of gifted poet and common man alike as far as we can remember. They are the starry seven of Keats, the fireflys tangled in a silver braid of Tennyson, the fire god's flame of the old Hindus, and the ceremonial razor of old Japan. No other celestial configuration appears so often on the pages of the poet.

Traditionally, the average eye can see six stars here, the exceptional eye seven, and 10 bear names or Flamsteed numbers, as the accompanying chart shows. In the sooty skies of our populated areas, it is not uncommon that no stars can be distinguished; the eye sees just a shimmering patch. In the marvelous air of Arizona, the writer has counted 14 stars with ease despite his "class two eyes." The number of Pleiades stars visible is really an index to the transparency of the atmosphere and the cluster does not make a valid eyesight test. Located near 3ʰ 45ᵐ, +24°, the group provides a magnificent object to introduce your layman friends to the glories of the stars, for in any telescope they make even the most blasé gasp for wonder and delight.

WALTER SCOTT HOUSTON



A chart of the Pleiades for telescopic use, with south at the top and east at the right. Stars indicated by circles are plotted from positions in the Boss catalogue. The points represent fainter stars, without regard to magnitude, plotted approximately from BD charts. Asterope is both stars 21 and 22. Diagram by Owen Gingerich.

MINIMA OF ALGOL

October 1, 5:28; 4, 2:16; 6, 23:05; 9, 19:54; 12, 16:42; 15, 13:31; 18, 10:20; 21, 7:09; 24, 3:57; 27, 0:46; 29, 21:35. November 1, 18:24; 4, 15:13; 7, 12:01.

These predictions are geocentric (corrected for the equation of light), based on observations made in 1947. See **Sky and Telescope**, Vol. VII, page 260, August, 1948, for further explanation.

VISUAL OBSERVING PROGRAMS FOR AMATEURS — VII

Which Telescope Shall I Choose?

THE NEWCOMER to the observing ranks is usually faced with the question, "Which shall I choose, a small refractor of 3- or 3½-inch aperture, a 6-inch reflector, a 4½- to 7-inch refractor or an 8- to 12-inch reflector?"

Parts IV, V, and VI in this series have given the fundamental data for making this choice, but each amateur knows his own specific requirements best.

For an observer who must have extreme portability because of tree conditions, or who travels a good deal, or who has only limited space in which to use or store a telescope, I should unhesitatingly advise a 2½-inch, 3-inch, or at most a 3½-inch refractor, preferably of f/12 to f/15 focal ratio, perhaps on a fork-type altazimuth mounting. This also would be my choice for those whose primary interest is the sun, and for anyone who can devote only a few minutes an evening to observing.

For those amateurs who want the utmost power at the minimum of cost for variable star work, the moon and planets, but cannot leave their telescopes permanently set up, the 6-inch Newtonian reflector on a fork-type mounting is well fitted to their needs. This too seems about the largest telescope which one can transport by sedan.

For observers who want steadier planetary views and greater convenience of operation than the 6-inch Newtonian supplies, and who can set up a semi-portable instrument each time they use it, a 5- or 6-inch refractor is probably the answer.

For those who can set up a telescope on a permanent pier and have time each evening to get their telescope unlimbered, 5- to 7-inch refractors, 7- to 10-inch reflectors of f/8, and 7- to 8-inch Newtonian reflectors of long focal length, say f/11 for planetary work, seem to be the most popular.

In my opinion, at least, only club observatories should consider 10-inch or larger reflectors.

I shall probably get letters violently disagreeing with everything that I say in this entire article. Some amateurs are so favorably disposed to refractors that I have been jokingly referred to by them as "a traitor to refractors." Other amateurs unhesitatingly say they "prefer a reflector under all conditions."

I have used refractors for 25 years and reflectors for 20. Alas, neither type is ideal, and I have given up the search for a universal visual instrument which will serve all purposes equally well. Shall we briefly summarize the strong and weak points of refractors and Newtonian reflectors?

Refractors are more versatile because one can use large wide-angle eyepieces as well as ordinary eyepieces, and can use a Herschelian solar eyepiece. In reflectors the secondary mirror is a definite bottleneck when it comes to using wide-angle eyepieces and solar eyepieces. Refractors are easier to point than reflectors; in fact, one has to point a reflector by using a refractor, namely, the finder. Above the 6-inch size one should really have three finders on a Newtonian reflector for convenience in all positions. The field of view with a refractor is more satisfying esthetically than in a reflector. I have tried to analyze why this is so, but cannot give the exact reason.

The achromatism of the mirror is an advantage that a reflector possesses, compared to the lack of perfect achromatism of even the best refractor. On the other hand, reflectors seem to me, at least, to suffer a great deal from unsteady seeing, some of which undoubtedly occurs in the tube itself. The balance of these two items seems to be in favor of the refractor, at least in New England where unsteady seeing is very prevalent. With the four Newtonians that I have had, I seem conscious always of a slight blurring of details. This may be atmospheric or it may be caused by the three diagonal struts that I have always used because such a support is simple and firm. It is not from poor optics, because knife-edge tests on the completed telescopes indicate excellent mirrors and diagonals.

Reflectors are commonly thought of as being more convenient to look through than refractors when observing near the zenith, but in practice there are parts of the sky where either type of telescope is very awkward to use, so this is a tossup.

Reflectors cost less for their objectives and cells than do refractors, but appurtenances and mountings are about equally expensive for either type.

In practice, which type of telescope do I use? I have my little "workhorse" refractor, my 6-inch reflector, and my 6.2-inch refractor in my basement, and I can pick any one of them to observe with that I choose. Ninety per cent of the time I choose the little refractor, and the larger reflector and refractor share the other 10 per cent of the time about equally. It is chiefly a matter of convenience, and a small refractor is more convenient to use than any other instrument of comparable capability.

DAVID W. ROSEBRUGH
79 Waterville St.
Waterbury 10, Conn.

PREDICTIONS OF BRIGHT ASTEROID POSITIONS

		h	m	°	′
No. 4	**Vesta**			Mag. 7.0	
Oct.	16	3	18.3	+7	43
	26	3	10.0	+7	05
Nov.	5	3	00.2	+6	30
	15	2	50.0	+6	04
	25	2	40.7	+5	51
Dec.	5	2	33.2	+5	54
No. 18	**Melpomene**			Mag. 8.2	
		h	m	°	′
Oct.	26	4	19.3	+01	52
Nov.	5	4	13.7	+00	20
	15	4	05.3	−00	37
	25	3	56.0	−00	57
Dec.	5	3	47.0	−00	45
	15	3	40.4	−00	01
No. 29	**Amphitrite**			Mag. 8.7	
		h	m	°	′
Nov.	15	5	21.7	+32	40
	25	5	12.8	+32	59
Dec.	5	5	01.9	+33	02
	15	4	50.5	+32	49
	25	4	40.2	+32	22
Jan.	4	4	32.5	+31	45

The above are predicted positions in right ascension and declination for the epoch 1950.0, for 0h Universal time. The magnitude is that expected at opposition. In each case the motion of the asteroid is retrograde.

VARIABLE STAR MAXIMA

October 5, RS Cygni, 7.4, 200938; 8, T Columbae, 7.6, 051533; 8, R Corvi, 7.6, 121418; 8, R Bootis, 7.3, 143227; 10, S Pavonis, 7.3, 194659; 11, Chi Cygni, 5.3, 194632; 15, RT Cygni, 7.4, 194048; 20, T Centauri, 6.1, 133633; 21, X Monocerotis, 7.6, 065208; 26, S Ursae Majoris, 7.9, 123961. November 4, R Virginis, 6.9, 123307.

These predictions of variable star maxima are by Leon Campbell, honorary recorder of the AAVSO. Only stars are included whose mean maximum magnitudes, as recently deduced from a discussion of nearly 400 long-period variables, are brighter than magnitude 8.0. Some of these stars, but not all of them, are nearly as bright as maximum two or three weeks before and after the dates for maximum. The data given include, in order, the day of the month near which the maximum should occur, the star name, the predicted magnitude, and the star designation number, which gives the rough right ascension (first four figures) and declination (bold face if southern).

PHASES OF THE MOON

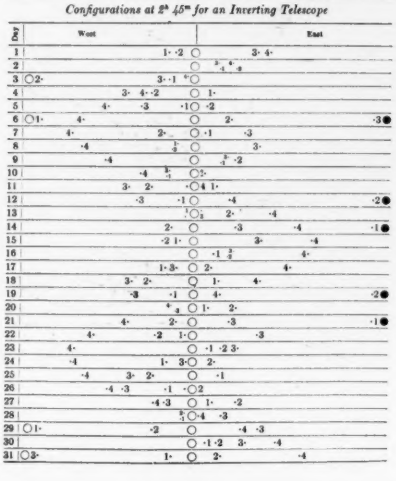
Last quarter	October	4,	7:53
New moon	October	11,	13:33
First quarter	October	18,	4:18
Full moon	October	25,	20:46
Last quarter	November	3,	1:00

	October	Distance	Diameter	
Apogee	1d 4h	251,800 miles	29′	29″
Perigee	13d 4h	224,300 miles	33′	06″
Apogee	28d 20h	252,400 miles	29′	26″

JUPITER'S SATELLITES

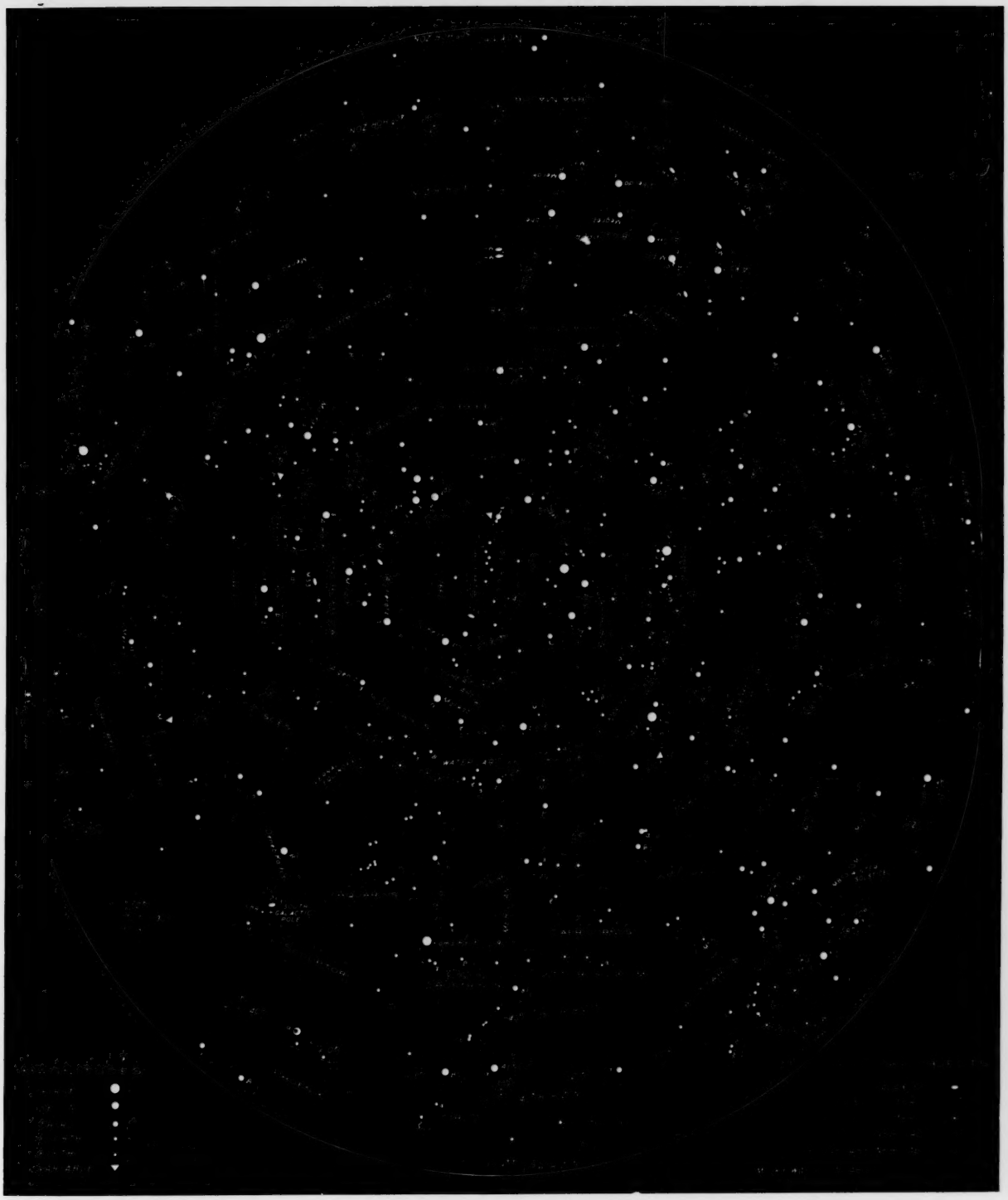
Jupiter's four bright moons have the positions shown below for the GCT given. The motion of each satellite is from the dot to the number designating it. Transits of satellites over Jupiter's disk are shown by open circles at the left, and eclipses and occultations by black disks at the right. Reproduced from the **American Ephemeris and Nautical Almanac.**

Configurations at 2h 45m for an Inverting Telescope



UNIVERSAL TIME (UT)

TIMES used on the Observer's Page are Greenwich civil or Universal time, unless otherwise noted. This is 24-hour time, from midnight to midnight; times greater than 12:00 are p.m. Subtract the following hours to convert to standard times in the United States: EST, 5; CST, 6; MST, 7; PST, 8. If necessary, add 24 hours to the UT before subtracting, and the result is your standard time on the day preceding the Greenwich date shown.



The sky as seen from latitudes 30° to 50° north, at 9 p.m. and 8 p.m., local time, on the 7th and 23rd of October, respectively.

STARS FOR OCTOBER

A SMALL diamond of stars commonly called Job's Coffin stands high in the western sky on October evenings. The origin of its popular name is unknown; the correct name, Delphinus, the Dolphin, dates back to ancient times. Etymologists were baffled by the names of Alpha and Beta Delphini, Sualocin and Rotanev, until it was realized that the Italian astronomer, Piazzi, had cleverly honored his assistant, Nicolaus Venator, by adding his name, backwards, to these stars.

Capricornus, the Sea Goat, was once the southernmost zodiacal group and thus the home of the winter solstice, but it has now been replaced by Sagittarius because of precession of the equinoxes. Today we might better have a Tropic of Sagittarius and a Tropic of Gemini, to keep pace with the sky.

A larger constellation, Aquarius, the Water Carrier, has followed Capricornus across the sky since ancient times, perpetually pouring water into the mouth of the Southern Fish, conspicuously marked by 1st-magnitude Fomalhaut, now rising higher in the south. An inverted Y of four stars in Aquarius lies on the equator; the Arabs called it the tent, but the present designation is the Water Jar, as shown on the chart.